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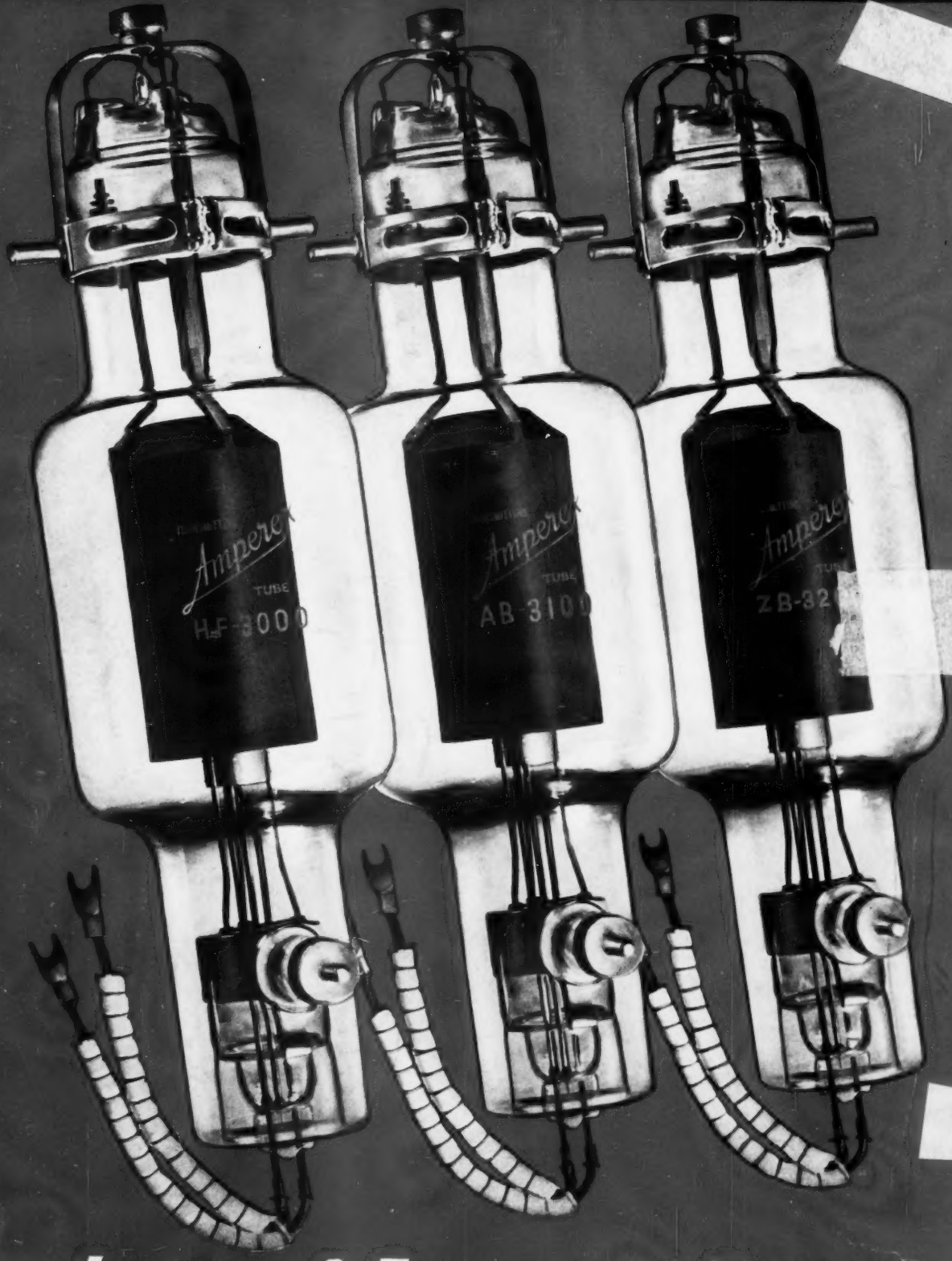

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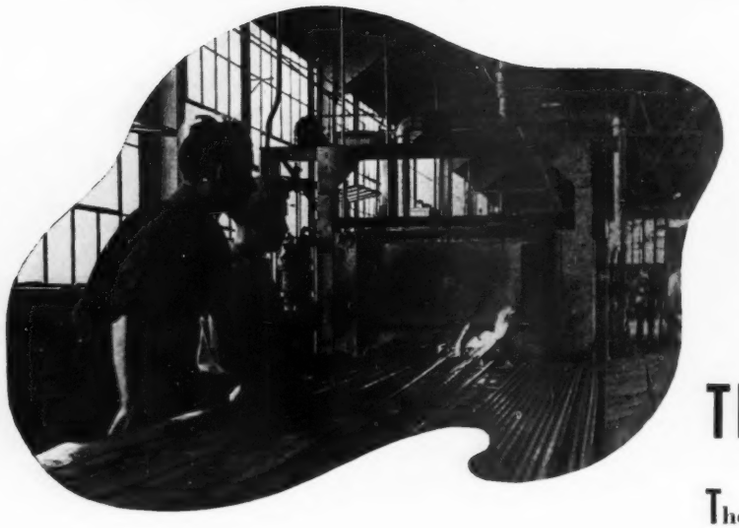

WHEN THE "HEAT" IS ON

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CROSS TALK

▶**FM** . . . As this is being written engineers, and others, at Washington are debating what to do with frequency modulation. In response to the article "Frequency Modulation, a Revolution in Broadcasting?" in our January issue of 1940, several interesting comments have been received. Two of them are quoted below as being characteristic.

"I believe the reason the public has not been sold on high-fidelity is because the public hasn't had any. My only contact with the subject, aside from my own band-pass receiver (TRF) has been confined to sound reproducing equipment in the theatres.

"In the early days, a typical electrical reponse of a good film-reproducing system was about as shown, and acoustically very much as given on Curve 2. Due to noise and irregularities of a mechanical nature which resulted in flutter, the h-f end had to be cut to avoid harshness and 'gargle' with a consequent decrease in intelligibility.

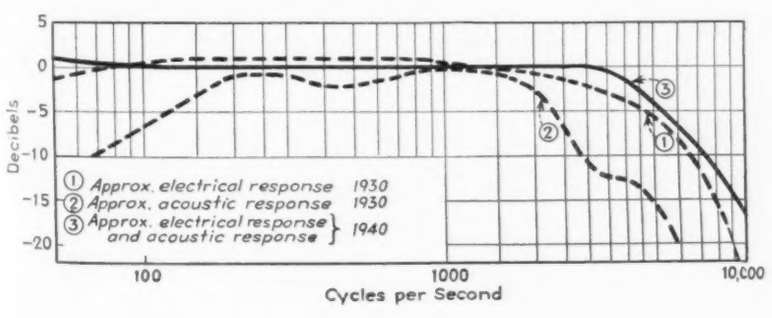
"The most modern systems use amplifiers and circuits designed to allow full rated power with a total distortion of less than 1 per cent (1 per cent is quite noticeable). Speaker mechanisms are more efficient and have a minimum of harmonic and phase distortion product, and improved scanning devices reduce the flutter content to less than 0.2 per cent. These improvements, combined with similarly advanced recording, plus noise reducing techniques have practically eliminated audibly reproduced extraneous noises and have allowed the extension of the frequency spectrum so as to resemble curve 3.

"Improved reproduction has been sold to the theater going public and the theater owner because there is a difference, and radio can do the same selling job when it gives the public something better."—Pierce J. Aubry, Birmingham, Alabama.

"Your article in the January, 1940 issue is very interesting to me even though I am strictly an amateur when it comes to radio mechanics, and even though I am completely unable to understand a lot of the technical terms you have used.

"However, there is one subject you cover that is more than passing interest to me; that is, the question of whether the public appreciates high fidelity or whether it doesn't. It is my opinion—still speaking strictly as an amateur—that the apparent apathy of the public is due not to lack of appreciation, but rather to inability to pay the premium prices now being charged for so-called high fidelity receivers. Time and time again I have heard people say, in effect, 'Sure, we like to hear high fidelity reception but we can't afford to pay $200.00 or $300.00 to get it. We can get along with $50.00 reception.'

"It would, therefore, appear to me that radio's problem is one of getting high fidelity at low cost rather than of getting the public to appreciate high fidelity. People will junk their old sets and buy new ones if the change-over does not mean the elimination of popular price receivers."—Louis E. Wade, President, Louis E. Wade, Inc., Fort Wayne, Ind.



Characteristics of sound motion pictures—1930-1940

▶**1930–1940** . . . This is *Electronics'* 10th anniversary issue. In it will be found a brief review of these 10 years of economic troubles and technical progress. Engineers are still eminently able to produce new things for people to use, but engineers, nor statesmen, nor politicians, nor sociologists have yet devised means whereby man's own nature can be harnessed to his own use. Mathematicians are still unable to solve equations with very many variables—and man and his society is controlled by hundreds of variables most of which seem to be negative in their effect.

Electronics is happy to note the number of its readers who state they are charter subscribers, that they have bound volumes since April 1930, and is proud to number among its advertisers so many who have been with us since the initial issue. *Electronics* hopes, fervently, that the next 10 years will see a new order in which peace, and prosperity and security and equity for all will be established.

FM

GETS ITS "DAY IN COURT"

With these words, Chairman Fly of the Federal Communications Commission opened the frequency-modulation hearing in Washington on March 18th. Testimony by Major E. H. Armstrong and by witnesses for F-M Broadcasters and R.C.A. is reported here

IN one of the largest gatherings of broadcast engineers and executives ever to assemble before the Federal Communications Commission, evidence on the past record and future possibilities of frequency modulation was presented in Washington beginning March 18th. At the time of going to press, two weeks later, all the evidence had been presented. Some 29 organizations and individuals had filed their intention of appearing before the Commission, and in all 50 witnesses expected to give testimony. The present report is concerned primarily with the testimony of Major E. H. Armstrong and F-M Broadcasters, Inc., whose witnesses appeared in the early days of the hearing and that of R.C.A. which was given in the second week.

The purpose of the hearing, revealed by the issues of the agenda issued by the Commission, was to determine:

(1) Whether aural broadcasting on the frequencies above 25,000 kc has reached such a stage of development that it is acceptable for rendering regular as distinguished from experimental broadcast service to the public;

(2) The relative merits of frequency modulation and amplitude modulation when employed for aural broadcasting on frequencies above 25,000 kc;

(3) The relative merits of wide band and narrow band frequency modulation when employed for aural broadcasting on frequencies above 25,000 kc;

(4) Whether it is possible to allocate sufficient frequencies to accommodate stations employing frequency modulation (narrow or wide band) to provide a satisfactory program service in the United States when considered in the light of the frequency needs of other services, including television, Government, aviation, police, common carrier, amateur, etc.;

(5) Whether it is possible to allocate sufficient frequencies to accommodate stations employing amplitude modulation to provide a satisfactory program service in the United States when considered in the light of the frequency needs of other services, including television, Government, aviation, police, common carrier, amateur, etc.;

(6) Whether it would be practicable for the Commission to authorize both amplitude and frequency modulation for aural broadcasting stations operating on frequencies above 25,000 kc, or whether the Commission should recognize but one of these forms of modulation for such stations;

(7) The possible future effects of ultra-high frequency broadcasting upon standard broadcasting on the band 550–1600 kc;

(8) Whether existing allocations of frequencies above 25,000 kc to particular services shall be modified to provide frequencies for aural broadcasting;

(9) The existing patent situation respecting frequency modulation and amplitude modulation for aural broadcasting stations operating on frequencies above 25,000 kc.

The present status of frequency-modulation, so far as the affairs of the Commission are concerned, was summarized in terms of the present channel assignments, licenses, construction permits and applications. The channel assignments to f-m are 26,300, 26,500, 26,700 and 26,900 kc; 42,600, 42,800, 43,000, 43,200, 43,400 kc; 117,190, 117,430, 117,670, 117,910 kc. As of March 12, there were 22 licenses and construction permits issued to f-m stations, all of which except one have assignments in the region from 42.6 to 43.4 Mc. On the same date there were 75 applications for f-m construction permits, and two applications for a-m permits in the u-h-f bands. All except two of the f-m applications request assignments in the 42.6 to 43.4 region of the spectrum.

Attention was focused on the band of frequencies from 41 to 44 Mc, not only because of the great number of f-m applications in this band, but because the witnesses urged that this is the most desirable portion of the spectrum for f-m transmissions. In this region, f-m assignments share the space with assignments to a-m educational stations (41.02 to 41.98 Mc), a-m broadcasting stations (42.06 to 42.46 Mc), and a-m facsimile broadcast stations (43.54 to 43.94 Mc). A good deal of the testimony related to the possibility of converting these a-m services to corresponding f-m services, and thus allowing a continuous band of f-m channels. The other questions had to do with the desirable width of channel for an f-m broadcast station, which in turn would determine the number

Major E. H. Armstrong brackets a portion of the u-h-f spectrum for the inspection of Federal Communications Commissioners (left to right) Craven, Brown, Chairman Fly, Walker, and Thompson. The inventor of the wideband f-m system testified for seven hours, urged that space be taken from television to allow more f-m station assignments

of channels which might be accommodated in this and any other portion of the spectrum.

Major Armstrong's Testimony

The first witness, for alphabetical as well as other reasons, was Major E. H. Armstrong the inventor and chief proponent of the wideband f-m system. Major Armstrong testified for a total of some seven hours, covering nearly two full days of the hearing. The early part of his testimony had to do with the history and principles of frequency modulation, both of which have been amply covered in past issues of *Electronics**. The early experiments in 1934 were recalled, in which tests were conducted from the NBC 2-kw transmitter located on the Empire State Building and operated in the 40-Mc band. Armstrong read into the record excerpts from a report on the results of these tests which showed an improvement in range of roughly two and one-half times in favor of narrow-band f-m over a-m in the same frequencies, and a further increase in range of nearly two times in favor of wideband f-m. Other results taken from the same tests indicated an improvement of 16 db in favor of f-m. The decision to erect the 40-kw f-m station W2XMN at Alpine, N. J. was made in April 1935 by Major Armstrong. Sound records made on film later in 1935, were then demonstrated to the Commission to illustrate the difference between f-m on ultra-high frequencies and a-m on the standard broadcast frequencies, over a path of about 85 miles. These records were the same ones demonstrated to the I.R.E. at the original presentation in 1935. The advantage in favor of f-m was so marked, and the static so prominent on the a-m portions of the film that Chairman Fly asked that the final record be turned off before its conclusion, granting the demonstration as conclusive. Major Armstrong then pointed out that part of the improvement in the f-m case, so far as the lesser degree of static is concerned, was due to the use of the

* The complete bibliography of articles on frequency modulation appearing in *Electronics* is as follows:

Frequency Modulation Advances, June 1935, p. 188.
Phase-Frequency Modulation, Nov. 1935, p. 17.
High-Power Frequency Modulation, May 1936, p. 25.
Noise in Frequency Modulation, May 1937, p. 22.
Frequency Modulation Demonstrated, March 1939, p. 14.
A Frequency Modulation Receiver, June 1939, p. 32.
Frequency Modulated Transmitters, Nov. 1939, p. 20
Frequency Modulation—A Revolution in Broadcasting? January 1940, p. 10.

higher frequencies, inasmuch as natural static decreases roughly in proportion to the increase in frequency. But discrimination against man-made noise, especially prominent in the high frequencies, high quality, low signal-to-noise ratio, greater range for a given realizable fidelity —all these were pointed out as definite advantages of the f-m system on any frequency, in addition to discrimination against whatever natural static does exist.

The performance record of station W2XMN in Alpine over a period of 900 hours operation from July 18, 1939 to the end of that year was then read into the record. A total of one and one half hours off the air was accounted for on the basis of r-f amplifier tube failures, but no lost time could be attributed to the operation of the f-m circuits. Power failures and noise on the telephone line were also given as causes of shutdowns. In all, the performance compares favorably with that of the standard broadcast transmitter of the same power rating.

In response to cross-examination by Commissioner Craven it was brought out by Armstrong that a frequency-modulation transmitter cannot be said to have a secondary service area. The primary service area of a 50-kw station extends to about 100 miles, if a reasonably high (of the order of 1000 feet) and reasonably efficient antenna structure is used. Beyond this limit, the signal becomes so weak that the amplitude-limiter in the receiver fails to function, and the service becomes useless. It was pointed out in later testimony that the service area also depends, in the same manner, on the receiver sensitivity, since the limiter action fails in an insensitive receiver at higher values of signal strength. Hence to take full advantage of the primary coverage of an f-m station, high sensitivity (well under 50 microvolts for full limiter action) receivers are required, and should be made available by the set manufacturers. Abnormal refraction of the u-h-f waves occasionally gives a "secondary" service but the service is not reliable.

Regarding the noise advantage of f-m over a-m in the same band of frequencies, Armstrong testified that when the desired signal is more than twice the undesired signal, an advantage of 1000 times in power, in favor of f-m, is obtained with fluctuation noise (tube hiss, etc.) and 100 times against impulse noise (ignition, etc.). In general the figures followed closely those quoted in the January issue of *Electronics*, pages 10–14. Armstrong reported considerable fading at the edge of the service area of an f-m station, both rapid and slow in character, but no selective fading, so that there was no audible evidence of the fading so long as the signal strength required for limiter action was available.

The wideband vs narrowband question for f-m stations is of importance since the channel width assigned to f-m stations determines the number which can be assigned in a given band. Armstrong gave 200 kc as the channel width for a wideband system and perhaps 40 kc as the channel width for a narrowband system. He stated that the power required for a given signal-to-noise ratio was about 25 times as great in the narrowband case, since the desired signal output would be one fifth in voltage for a frequency swing one fifth as great. He pointed out also that receiver design is more difficult in the narrowband system (because of the oscillator drift problem), and that multiplexing of facsimile and binaural transmission would be much more difficult in the narrowband case.

Regarding the available channels now assigned to f-m, Armstrong testified that those in the 40-Mc band were satisfactory, those in the 117-Mc band less so (but still useful) because of the difficulty in producing high powered transmitters and sensitive receivers (and also as revealed later because of the more prominent "shadows" cast by obstacles in the path of the waves); while the assignments near 25 Mc were considered practically useless because of the effects of sky-wave interference. He urged a single continuous band of f-m assignments, to simplify receiver design. He urged that a larger band be made available around 40 Mc, and another near 80 Mc, stating that in his opinion the new f-m service had a better claim to this space than did television. Specifically, he requested a transfer to f-m of the space of one television channel, but did not specify which channel. If ten channels were available for f-m, he said, a fairly good allocation job could be done for many parts of the United States, but not in the congested New England and New York area. If 30 to 40 channels were available, the needs of all could be taken care of for "a very long time to come".

Major Armstrong envisaged two classes of f-m service corresponding roughly to the regional and local classifications now used in standard broadcasting. The regional service would be offered by powerful, say 50-kw, stations located on tall buildings or mountain peaks, which would be protected against interference to the limit of their range, say to the 5 or 10 microvolt contour. The lower-power local stations could be placed as close as 20 miles or less, and if assigned to same channel would have correspondingly restricted service areas. In the interference areas between such stations, simple antennas with reversible directivity could be used to select which of the two stations was desired. It was emphasized that the interference between stations is audible only when the ratio between signal strengths is less than 4-to-1, and this degree of differentiation can ordinarily be introduced by directional antennas.

Concerning other items on the agenda, Major Armstrong stated that the effect of f-m on standard broadcasting would be to decrease congestion on the standard broadcast frequencies, and allow a better service to be rendered to the scattered rural population which he agreed would have to be served by standard broadcasting. He predicted a gradual shift in the public listening from a-m to f-m as more f-m receivers became available at lower prices, and as more stations offered the service. That present day f-m receivers and transmitters are reliable and out of the experimental stage was definitely stated. F-m transmitters cost no more, and perhaps less, than standard-frequency a-m transmitters of the same power. F-m receivers cost more only because of the superior audio circuits and loudspeaker system, which would be necessary in an a-m set to obtain the same quality. Prices for f-m receivers ranging from about $65 for an adapter to $375 for a de-luxe f-m and a-m receiver were reported. These prices are capable of steady reduction, as has occurred in conventional re-

(*Continued on page* 74)

A DECADE OF ELECTRONICS 1930 • 1940

ON the following pages will be found a resume of some of the important events that have changed the fields of the electron tube as they existed in April 1930 (when *Electronics* first was published) to the way these industries are constituted now—on the 10th anniversary of this publication.

In April 1930, sound, via the amplifier and the phototube, had barely come to the motion pictures, engineers were dreaming of the impact of the electron tube upon industry in all its manifold phases; radio was annually overproducing, and wondering when the market for radio receivers would be saturated.

Today, April 1940, no motion picture theater can operate without vacuum tubes; industry, except for welding, sees no revolution due to electrons in motion; radio, blasé, sees no saturation but hopes for television and other things new.

Whatever the next decade may bring, electronic engineers may look with pride on their accomplishments from 1930 to 1940. There has been no depression in science or engineering!

By KEITH HENNEY, EDITOR, ELECTRONICS

1930 ..A DECADE O

TEN years ago this month *Electronics* made its first appearance. Its readers were recruited from the membership of the learned and engineering societies. In a circulation campaign, unique in the annals of McGraw-Hill for its immediate success, potential subscribers were told that a new era had come, an era in which the electron tube would conquer industry as it had conquered communication and as it was revolutionizing the motion picture industry. Readers responded with amazing alacrity; they wanted the new paper. Clearly there was an interest in and a need for such a periodical.

What would *Electronics* be like?

In the initial issue, O. H. Caldwell, its editor, said *Electronics* would be a "clearing-house for facts, a camp-fire for counsel". Ten years ago it seemed certain that the economic crash of 1929 would provoke only a temporary stoppage of the wheels of industry, and that another year would see America well on its way again to new economic levels. The new paper would help engineers keep abreast of what other engineers were doing and, working together, scientists and technical men would aid in creating a new era.

In the following decade the editors and publishers of the new paper have striven to make it the clearing-house for facts, a camping-ground for counsel and in a measure have succeeded. Each year of those 10 has promised to be the last year of the depression; economically everything would soon be on the upgrade; all such promises have been broken. Technically the 10 years have been most successful, engineers never cease to produce new products from the brain children of the scientists. Even a casual perusal of the bound volumes of *Electronics* for the ten years will provide a feeling that technology always moves forward.

What was the industry worrying about 10 years ago?

In the first issue, pains were taken to point out the important characteristics of the pentode tube, then coming over the horizon for the first time. There was much controversy over this multi-element vacuum device. Should it be permitted to enter the radio industry? Was it not just one more complication to upset manufacturers, dealers and set owners? Why should there be a new tube? The screen grid tube had not been thoroughly digested, but here from Europe was another complex structure. As a matter of fact there were two kinds of pentodes, according to writers in the initial issue, April 1930. There was an r-f tube and one designed for power output. Neither was much good, according to present-day standards, but both seemed mighty unpleasant new products to the radio tube and set industry which was pretty satisfied with itself.

Today, pentodes of all sorts have practically removed the demand for tubes of the simple types used in 1930. All those who objected so strenuously to introduction of new tube types have had to take them in their stride, and to witness an expansion of the receiving tube list that in 1930 would have seemed as impossible as present-day tube prices.

In this first issue, S. M. Kintner, manager of the Westinghouse research laboratory discussed the industrial uses of the vacuum tube and spoke of its place in industry. Long an electronics champion at Westinghouse, Mr. Kintner, friend of all research, unfortunately did not live to see all of his hopes achieved.

In this first issue, Dr. A. N. Goldsmith lamented the fact that sound reproduction in the theater was so poor. It was standard practice, then, to cut off all frequencies above 3500 cycles to get away from ground noise. All that is gone, of course, and in the better theaters today it is possible to listen to sound quality seldom achieved by the better radio receivers.

A Revolution in Motion Pictures

One of the original editorial staff members, F. S. Irby, related the economic revolution produced in motion pictures by the advent of sound. Then there were 22,000 theaters showing pictures in the United States and of these, about 9,250 had been equipped for sound in the two years that had elapsed since the "Jazz Singer" (October 1927) had given movie goers a new vision, one in which they could hear their favorite stars as well as see them in motion. Now, of course, no theater which does not have sound equipment can even open its doors. Its lights are permanently dark.

"At the beginning of 1927 there were perhaps not 5 companies engaged in the manufacture of sound apparatus. By the end of 1929 there were 154 manufacturers in this field and as many as 182 makes of sound reproducing apparatus on the market". Most of these manufacturers have disappeared in the ten years that have elapsed since Dr. Irby presented these statistics.

In several issues following the initial April 1930 *Electronics* there was much discussion of the wide film (Grandeur) then proposed as another motion picture innovation. Wide film no longer plagues the minds of producers and exhibitors.

In the first issue W. C. White of the General Electric Vacuum Tube Engineering Department brought engineers up to date on the possibilities of the magnetron tube. Then it was possible to generate frequencies as high as 100 megacycles (a term not used in those days) and powers as great as 2.5 kw had been produced at 75 Mc. Dr. Mendenhall of the Bell Laboratories described the new double-ended high frequency tubes engineered for the transatlantic telephone circuits. The

240-A water cooled tube would generate 10 kw and the air cooled 251-A would produce 1 kw at 30 Mc.

Among the new products mentioned in the first issue were several from companies which no longer exist. Arcturus offered the Photolytic cell, a liquid photovoltaic cell in a handsome container. It listed at $31.50. Ten years later (1940) Arcturus as a tube producing company gave up the ghost, unable to make a profit from making tubes at present low retail prices.

Jenkins Television offered the Radiovisor kit for $75 without the neon lamp. It would produce television images about 2-inches square, 48 lines, 15 pictures per sec. DeForest Radio presented a short wave receiver "radical in appearance". Four tubes (types 22, 01-A and 12-A) and a series of plug-in coils, the latter stuck up on top in a jaunty and much too exposed fashion, constituted the essential components. It would cover the range from 20 to 200 meters.

Of 11 new products described in this first issue from 11 manufacturers, only one remains in modified form, and of the 11 companies only 4 are in existence today.

In the News section, mention was made of a new set of equations from Professor Einstein, still in Berlin, relating gravitation and magnetism, and of the R.M.A. committee to study the pentode situation (no set manufacturer would use the things in their 1930 production), and plans were described for the supercollossal R.M.A. Radio Trade Show to be held in Atlantic City in June.

In a department devoted to brief summaries of U. S. patents were names such as Harry Nyquist, Alva B. Clark, E. L. Chaffee, Samuel Ruben, R. H. Ranger, John H. Miller, Abraham Esau, F. A. Kolster, G. W. Pierce, H. C. Rentschler, Donald G. Little, Robert L. Davis, Carl F. Goudy, H. C. Dunwoody, O. T. McIlvaine. Patent numbers ran from 1,748,000 through 1,750,000. In the February 27, 1940 issue of the Official Gazette of the U. S. Patent Office the numbers are up in the 2,192,-000—nearly a half million patents had been issued in this ten-year period, surely no period of inventive depression.

The mast-head of *Electronics* of that initial issue bore four names. O. H. Caldwell was editor, a veteran McGraw-Hill editor, first of *Electrical World*, where he invented *Electrical Merchandising*, becoming its editor. Here he invented *Radio Retailing*, becoming its editor. And here he invented *Electronics* and became its editor. Mr. Caldwell left *Electronics* in 1935 founding a paper of his own. As associate editors were Franklin S. Irby and Keith Henney. Dr. Irby came from E.R.P.I. and represented the motion picture industry to *Electronics* readers. A Ph.D. under Michelson, a Lieutenant Commander in the Navy, Dr. Irby left *Electronics* several years after its founding and subsequently took a degree in law and has been admitted to the bar. Today he is in the legal department of 20th Century-Fox Films. Keith Henney was drafted from his job with *Radio Broadcast*, a magazine long since defunct but remembered fondly by old timers in the radio industry. His contribution was his knowledge of the radio industry from the technical angle attained by experience during the war as radio operator, and as engineer at the Bell Laboratories, by technical training under Professors Pierce, Chaffee and Field at Cruft Lab and finally by his 5 years on *Radio Broadcast*. He, alone of the original editorial staff, continues on *Electronics*, now its editor. The fourth member of the editorial staff was Dr. DeForest, consulting editor. Always bullish on electronics, Dr. DeForest has often contributed sage advice and worthwhile information to the periodical during its 10 years existence.

A feature of the initial issue was a colored chart giving the radio spectrum as it was divided in 1930. Frequencies higher than 23,000 kc were assigned for experimental and amateur use. At 60 Mc the spectrum ended for there seemed no way to generate frequencies so high in quantities great enough to be useful. This chart became so popular that it was revised in 1932 and 1936 and now appears again in this anniversary issue.

May to December, 1930

In the remaining issues of the first year, important new uses for tubes were disclosed, and events which presaged later developments of considerable importance were first described. In May, Page and Carpenter, General Electric engineers, reported on the production of artificial fevers by means of high frequency fields. Since that day the application of high frequency equipment to the needs of the medical profession have been very great. A by-product of this development has been much interference to communication channels by therapeutic apparatus.

In May 1930, the editorial pages carried a fervent plea to those who controlled broadcasting not to limit transmitting power. This theme will be found repeated many times in the following 10 years, for engineers know that only good strong clear signals provide the listener with good program service. Jefferson Electric Company offered a tube checker in the May issue. It had 6 sockets, one each for the 226, 227, 224, 247, 171A and 280 type tubes.

On May 22, Dr. E. F. W. Alexanderson demonstrated television on a screen 6x7 feet, made possible by means of a high intensity arc, a new light valve (a Karolus cell) and general improvements to existing apparatus.

At the Trade Show in Atlantic City in June of 1930, engineers seemed to have displayed considerable boredom at the offerings of the set manufacturers. There was nothing startlingly new, "nothing to compare with

the introduction of a-c tubes, the dynamic speaker, or the debatable advantages of the screen-grid tube". Everyone seemed to be jumping into the public address field. One radio manufacturer provided the set owner with short wave reception by means of a separate chassis. Receivers were good enough to cause one speaker to state that sound pictures were still inferior to radio in tone reproduction. The big thing for 1930 was to be tone control, by which the listener could get more effective bass by reducing the actual treble response. This was great stuff, according to those in attendance at the Trade Show; and has continued to be great stuff ever since. A tone control is a very inexpensive device to cover up bad design and troubles due to inferior components.

At the Trade Show Mr. Aceves demonstrated high quality reproduction attained by proper compensation in the amplifier of record and loud speaker deficiencies. The audience of engineers was enthusiastic, but sales departments decided that high quality was all right for engineers but not for the public. Ten years later this impression is still prevalent.

Many Radios Still to be Sold

Saturation of radio receivers in American homes as of June 1930 was about 30 per cent. One out of every 5 non-radio homes was to buy a radio in 1930; and there were 2 million battery sets still in use. Only 7.7 million a-c receivers had been sold.

In August 1930, *Electronics* made much of the quarter-million dollar "temple of electronics" that John D. Rockefeller, Jr., was to erect in cooperation with R.C.A. and N.B.C. Three city blocks were to be razed for Radio City.

The market for home talking movies was appraised in September—a market that never appeared, much to the distress of several manufacturers who got caught in the vicious circle made up of the facts that no one would buy home equipment until there was a library of sound pictures available, and that no one would put the money into building up a library until there were many reproducers already in home use.

In September, B. J. Thompson, then of the vacuum tube engineering department of G.E., described the development of the FP-54 tube, a tube which will measure 10^{-17} amperes and will indicate the flow of current represented by 63 electrons per second. In the 10 years since this tube was first produced, many hundreds have found their way into research laboratories, astronomical observatories and other places where a sensitive electrometer tube can be utilized. The 230, 231 and 232 types of tube were introduced—operating from 2-volt batteries and requiring 0.06 to 0.15 amperes for the filaments. In November, National Carbon presented the radio world with its 2-volt Air-Cell battery, an important contribution to listeners in powerless homes.

George Throckmorton was then executive vice-president of the E. T. Cunningham Company. E. A. Nicholas had just been appointed Radiola distributor for northern Illinois. Gene Tracey had gone to the West coast to discuss the possibility of erecting a new plant for National Union Radio there; Milton Alden and Elinor Johnson had formed a new company known as the Alden Products Company. Triad in Pawtucket announced a new and improved 210 type of tube, R.M.A. was worrying about the usual overproduction and subsequent dumping of radio receivers. Jensen Radio Mfg. Co., announced midget speakers for automobile or "mantle" receivers. They listed at $15.00. Nowadays one can purchase, speaker, tubes, cabinet and all the components for less than this figure. In November 1930 there were 29 cities using radio service as adjuncts to their police departments and the rapid expansion of this service was signified by the fact that 22 other cities held construction permits. Howard W. Sams was general sales manager of Silver-Marshall.

The total cost of making a radio tube in late 1930 was 41.6 cents, half what it had been two years before; and it was estimated that the production of receiving tubes would mount to 69 million by the end of the year.

In November Mr. Walter F. Gifford, President of A.T.&T. said "As sure as I am standing here, this depression will soon pass. We are about to enter a period of prosperity, the like of which no country has seen before."

At the year-end of 1930 certain accomplishments had been recorded. Among them are the following: Westinghouse invented the ignitron which proved to be a very practical controlled rectifier suitable for handling high power especially in those applications where the ratio of average current rating to peak current rating was very high. Resistance welding had found a new and powerful tool. Telephone service was opened between the United States and Australia; the Bell Laboratories had demonstrated phone-booth two-way television; R.C.A. demonstrated transmission of maps and news to ships at sea by facsimile; Ballantine developed the variable-mu tube (551), Western Electric introduced noiseless film recording. September, 1930, C.B.S. broadcast its first Philharmonic Orchestra program.

1931

Midget sets were the rage at $55; the superhetrodyne, which came into wide service in 1930, became the standard circuit in spite of bad radiation characteristics; Merlin Aylesworth, president N.B.C. said "The majority of business men will have radio sets in their offices in 1931;" "toe recording" of sound on film was described in January 1931 *Electronics* by George Lewin and in this issue will be found a summary of opinions on the historic struggle to determine who invented the high vacuum. On May 25 the Supreme Court declared the Langmuir patent invalid and the Lestein Corp. of America advertised the Lestron 110-volt tube.

Hawaii, Oahu, Maui and Kauai in the Hawaiian Islands were interconnected by u-h-f radio circuits by R.C.A. for an inter-island communication system. Traffic was controlled by phototube installations in East Liberty, Penna. R.C.A. noiseless recording sound in film was introduced.

Radio sets sales in 1930 were reported in March *Electronics*. Sales were less than in 1929, dollar volume

was off to a figure nearly one-half that of 1929. The year saw a total radio set, tube, and accessory business of about a half-billion dollars compared to 842 millions the year before. The depression was really getting under way.

There was much squabbling among tube people as to the final design characteristics of the variable-mu tube, the major difficulties existing between the R.C.A. 235 and the Arcturus 551 (Ballantine's tube). The 235 won. C. W. Stone of G.E. extolled the virtues of d-c power transmission—but to date an experimental installation is as far as thyratrons and big rectifiers have gone toward revolutionizing the power networks. Clause 9 was causing much trouble, deForest Radio getting a permanent injunction against R.C.A. in February in the Federal Circuit Court of Philadelphia. Editor Caldwell prophesied "organless, choirless, bellless and preacherless churches in 1940," all by electron tubes. All through 1931 occurred bitter wrangling between the components suppliers and the radio set manufacturers over price. Quality of receivers hit an all time low; poor workmanship, poor tone fidelity, low prices.

At the Trade Show, Stevens Hotel, Chicago, was displayed a permanent magnet loud speaker, first of a long line of speakers supplying their own field energy. Tube manufacturers were developing fancy testers as inducements to dealers to sign on the dotted line for tube franchises. Sanabria demonstrated 45-line television on a 6-foot screen using a high-intensity low-cost tube made by Taylor; General Radio displayed the Von Ardenne cathode ray tube for measurement purposes; engineers were shocked by holding the wrong end of a large Rochelle salt crystal; 71 per cent of all set models displayed were supers, 73 per cent used pentode tubes and 94.5 per cent used variable-mu tubes.

Late in the year, 1931, *Electronics* and other McGraw-Hill publications moved into their own building at the present address, 330 West 42 St. On Christmas Day, N.B.C. broadcast Hansel and Gretel from the Metropolitan Opera House.

1932

The new year opened with recognized liabilities:—radio overproduction, engineer unemployment, financing troubles, idle factory capacity. The assets:—a hoped-for automobile market for 300,000 receivers and a hoped-for increase in interest by industry in the vacuum tube as a control agent.

In January N.B.C. was completing the first television antenna on top the Empire State building, 1250 feet above the sidewalk. The R.C.A. field test of television had already begun, 8 years ago! The Federal Radio Commission, forerunner of the F.C.C., admitted that television progress had been made in 1931 but was not inclined to open the bands to paid television until more progress had been made. Mechanical scanning was used at Empire State, 120 lines 24 frames and engineers who had seen the picture were pleased. "Within six months a two-foot picture is expected with a million-cycle sideband required." "It is extremely doubtful if any large scale sales can be possible before 1933."

Mercury vapor tubes were threatening the existence of the 80 type tube, a threat which has not come to any fruit. Tube prices to set manufacturers averaged about 40 cents following a cut in prices near the end of 1931.

In the first 1932 issue of *Electronics* E. W. Ritter, Research and Development laboratory of R.C.A. Radiotron, described the benefits of utilizing the suppressor grid in a pentode for r-f purposes. This was the 239, the forerunner of a long family of multi-element tubes for preliminary amplification and frequency conversion stages.

At the first of the year automobile radio problems were many. There was no really good converter of power for the receiver; the sets cost too much (much more than 10 per cent of the cost of the car)—and free wheeling (then the potential rage of the automotive world) was creating havoc with the charging problem. At the New York Automobile Show in January Mallory showed a half-wave rectifier using a Raytheon tube; Bosch demonstrated its "Magmotor." Prices for these convertors of several types were of the order of $25 to $30, high prices indeed just to convert storage battery power to a form useful by the auto radio set!

Auto Radio—the Great White Hope!

Early in the year engineers were discussing Class B amplification. David Grimes of the R.C.A. License Laboratory (established 1930) talked about it at the Chicago I.R.E. section in January, C. E. Kilgour of Crosley and J. R. Nelson of Raytheon wrote on the subject in *Electronics*.

During the early months, industrial applications of vacuum tubes involved phototube controlled elevators, continuous weighing utilizing a selenium bridge with amplified output, supersonic sterilization of milk, phototube control of humidity, synchronization of rubber conveyors using thyratrons. Several articles dealing with the theory underlying the several industrial types of tubes were published to acquaint engineers with the possible applications of such control devices. The theremin was being used by Dr. Stokowski and the Philadelphia Orchestra. Ranger and Miessner were both active in developing electric musical instruments.

Flexible cable was used for controlling automobile and home receivers by the Radio Vision Research Laboratory of the Federal Telegraph Co.

March 1932 saw the annual presentation in *Electronics* of industry figures. During 1931 some 3,340,000 receivers had been produced for the domestic market (471,000 for export) representing a dollar market of $212,000,000; 53.5 million tubes were made and sold for 69.5 million dollars. In spite of general business lethargy radio sales held up well. Slightly over 100,000 auto radios were sold at an average price of $55.

Automobile radios were still looking for ideal energy converter—12 being described in March at list prices varying from $18.50 to $40, most of them being rotat-

ing machines. Raytheon produced its LA automobile power output tube, which developed as much output as the 247 but with a filament power requirement much less.

Manufacturers were beginning the runaway announcement of new types of tubes. The 46 appeared, designed for class B, the Triple-Twin of Cable Radio for the same purpose and the Wunderlich detector double grid tube (this brought on the 55) arrived. Polydoroff was busy working on iron core coils.

In May, G. F. Metcalf of General Electric described a new cathode ray tube, the first evidence of the vast development of tubes of this general type. The FP-53 was a hot-cathode tube employing electrostatic deflection with anode voltages of 5000 to 10,000 volts. Allen DuMont had offered the first American cathode-ray tube in June, 1931. C. B. Upp of Westinghouse described the RJ-563 heavy duty industrial amplifier in the same issue.

W. P. Koechel of Ken-Rad had started his series of tube applications utilizing the "hole-in-the-meter" type of indication and control. During the early months there was much talk about Dr. Robinson's crystal filter receiver (the Stenode) circuits, and in May 1932 Professor Appleton of King's College discussed the important property of highly selective circuits of the Robinson type characterized by the fact that a strong signal demodulates a weak signal giving an effective increase in selectivity.

Radio Declines High Fidelity

Two-speaker receivers were tried out, discussed, and later dropped. Engineers were clamoring for their sales departments to permit a higher degree of tone fidelity in radio receivers, after having listened to phonograph recordings out to 9000 cps, motion picture reproduction (Providence, R. I.) out to 8000 cps. Broadcasters had pushed sidebands out to 7500 cps.

At the Stevens Hotel in Chicago in May the R.M.A. Trade Show displayed the wares of the new season. At the same time Radio Row (Cortlandt Street, New York City) was flooded with 1931 receivers "with as many big names as the movie 'Grand Hotel'." R.C.A. was threatening to bring out another tube; and the R.C.A. licensees saw cathode ray television demonstrated.

Clear channels in the broadcasting spectrum were slowly being whittled away limiting the useful range of these channels to local communities. The I.R.E. set up a committee to help unemployed engineers.

All-wave receivers amounted to 24 per cent of models shown at Chicago; 70 models used two speakers; class B was taking hold very fast, aided by the mercury vapor rectifier tubes; there were more higher priced sets shown than lower priced sets (comparing prices to the previous year) and the averages of the two groups seemed to be in the neighborhood of $43 and $39. Automatic tone control circuits were being developed (these never came into much use) and automatic muting circuits were appearing in small quantities. Adoption of the 6.3 volt line of tubes by Philco (tubes by Sylvania) had much to do with the later general use of these tubes by all set makers. The October 1932 issue of *Electronics* listed 300 different types of tubes on the American market. (During 1932 the number of receiving tubes nearly doubled.)

Later in the year circuits for driving push-pull stages from a single-ended driver stage (phase reversal circuits) were described; acoustically compensated volume controls which boosted the bass at low volume levels were in use, and "the universal dc-ac receiver made by International (Ann Arbor) is attracting much attention not only for its small size and low cost, but the ingenious scheme to take care of service problems." When the set needed repairs, the owner placed a dollar bill in an envelope, placed the envelope in a slot in the receiver provided for the purpose and shipped it back to the factory. The dollar-in-the-slot idea did not last long; but the ac-dc sets are here to stay. Receivers in which the owner could make recordings were being improved.

Settlement of the Government suit against R.C.A. occurred during the year 1932. By this consent decree, G.E. and Westinghouse divested themselves of R.C.A. stock, and R.C.A. was freed from competition in the radio set field for 30 months after which G.E. and Westinghouse could enter the hazardous business of making and selling receivers on their own.

Increased use of directional broadcast antennas occurred during 1932; and at the Fall Meeting in Rochester B. V. K. French gave his long-remembered analogies between the radio and the photographic art.

The year saw increased sales of phototube relays but the manufacturers knew only in few cases the usage to which these units of package goods were to be put. Electric signs were turned on and off automatically by phototubes; automatic batching and weighing was accomplished in a practical manner; eggs were candled by phototubes; thyratrons controlled steam boilers; razor blades were inspected, raw silks were tested for thread size, colors were matched and phototube guards were put on Radio City elevators. Messrs. Lord and Livingston of G.E. began a series of articles which continued over a long period, dealing with applications of tubes to counting, to welding, to timing, etc.

The ribbon type microphone was produced during 1932; automatic repeater stations for u-h-f were demonstrated, and multiplex operation of a single transmitter speeded up traffic.

By the end of the year the industry had disposed of 2,620,000 sets, 44.3 million tubes with a market value of $196,190,000, the smallest tube-set turn-over since 1927.

1933

In the January issue editors prophesied what 1933 might bring. Already tests from the Empire State had demonstrated the carrying power of high-altitude short-wave antennas. Engineers were becoming acquainted with automobile ignition interference. Signals from Empire State (2 kw at 44 Mc) were heard atop Mount Washington, and in Albany and Montauk

Point. An all-metal envelope tube had been developed at Schenectady. This was not the metal tube that later on jarred the radio set industry, this was a 100-amp industrial tube—but it pointed the way. The 25Z5 was on the way. A quarter million auto radios at about $45, it was hoped, would be sold in 1933. (Actually nearly 725,000 were sold.)

Inter-carrier noise suppression, amplified avc appeared. Description of the electron tube equipment in Radio City Music Hall appeared in the February issue. "It was the electron tube that made Radio City possible." Nearly a score of new receiving tubes were introduced in the early days of the new year. These were the 6.3 volt tubes and the 2A3, 2A5, 2A7—note the new numbering system. Gaseous indicator tubes appeared on radio receivers. Now began the urge to put two or more tubes in one glass envelope.

Old line manufacturers were caught napping by the midgets, and it took many of them a long time to get in on this market, almost the only market at the moment.

Auditory perspective or stereophonic sound reproduction was demonstrated over a wire circuit from New York to Philadelphia. Later Dr. Harvey Fletcher and his associates at the Bell Laboratories demonstrated the equipment in New York City. All-metal tubes (Catkin) tubes were announced in England and America, all unsuspecting, was not much interested. They did not take very well in England, and the Catkin is now a museum piece.

Radio Aids to Aviation

Harry Diamond of the Bureau of Standards demonstrated his blind landing system at Newark Airport. At the mid-years, industry codes under NRA occupied the time and worry of many industrialists; the ignitron was first described in *Electronics*, thyratrons were put to work welding the metal parts of all-metal high power tubes (another step toward metal receiving tubes.) Zworykin presented the iconoscope to the IRE June 26 meeting in Chicago; the Acorn tubes made their appearance early in the Fall and B. J. Thompson described them in *Electronics* (August 1933).

Indian summer, 1933 saw a surprising upturn in radio sales—but industry was worrying. Could NRA, NEMA-RMA code supervisors effect stabilization of the radio industry?

At the end of the year the balance-sheet of television stated these troublesome factors: lack of detail in pictures, high cost of receivers, expense of tube replacements, small range of transmitter, difficulty in chaining stations together for network programs, tremendous studio expense,—who will pay for television? Many of these problems still vex television people.

Five hundred kilowatts went on the air at WLW in 1933 and continued to be the talk of the industry in the following year. It was hoped that other really high power stations would keep WLW company—but this wish never materialized. Facsimile as a broadcast service to the public began to be talked up, and in 1940 it was still being talked about but without widespread use. Between 600,000 and 700,000 auto radios were put in cars during 1933. Home receivers during 1933 sold to the number of 3.7 million with a retail value of $130 million; tubes to the number of 63 million. Auto-radio vibrators were selling to manufacturers for about $1.50; components were selling to set makers for about one-third of the 1930 prices. Hazeltine engineers delivered a series of papers on high fidelity at the Philadelphia I.R.E. annual convention.

1934

Shield grid thyratrons (Livingston and Maser, April 1934 *Electronics*,) appeared; double cathode phototubes were being used for sound on film recording, engineered by Dimmick of R.C.A.; television from Empire State to Camden was demonstrated to members of the press. Tower antennas for broadcasters were coming into greater use. Farnsworth demonstrated his electron multiplier tube utilizing secondary emission. Associated Press installed a large inter-city photograph transmission system engineered by Western Electric.

Donald G. Fink, of M.I.T., joined the editorial staff of *Electronics*.

Tombstone models of receivers, more new tubes, airplane dials, program pre-selecting mechanisms provided highlights for the year. Messrs Pike and Metcalf, G.E., described the all-metal industrial tube.

During the year 1934, C. J. Young, Otho Fulton, J. V. L. Hogan continued work on home facsimile. Station WTMJ installed a Hogan "radio pen" but "no immediate commercialization is planned." At the end of the year radio sales were running ahead of the previous year by an estimated 40 per cent; 4.7 million receivers were sold.

Metropolitan Opera House installed tube controlled lighting system; tube operated voltage regulators were being used in photometry; and the department "highlights of electronic devices in industry" continued to point out many applications of phototubes, amplifiers, cathode ray tubes and other members of the tube family to non-communication problems.

Late in 1934 S. Y. White read a paper before the Radio Club of America on "signal-seeking" circuits (*Electronics* January 1935) and opened up a whole new box of tricks. Automatic frequency control came in; and later went out aided by components whose frequency shift with temperature, and humidity and time became negligible.

A 400 kw tube-commutated motor was described before the A.I.E.E. in January, d-c power transmission came in for more talk, the co-axial conductor system was described.

Edgerton was working on his high speed photography experiments, later to give a new and remarkable insight into many of the motions of nature and of man's creations.

And on April 1, 1935 R.C.A. and G.E. disclosed and described the all-metal receiving tube. On April 26 Major Armstrong announced to the newspapers that he had developed a system of frequency modulation for use on high frequencies which reduced the noise level to such an extent that the range of 7-meter stations could be quadrupled. Electron beam tubes were discussed by B. J. Thompson at the Annual I.R.E. convention (this led to the 6E5 tuning indicator tube), F. B. Llewellyn received the Morris Liebmann prize.

September 1935 *Electronics* appeared in new dress, on better paper, and with expanded editorial contents. Since that date the paid circulation to the publication has doubled and each year sees an increase in the number of readers.

Automatic SOS alarms were developed. Volume expansion in radio sets came in with a boom and went out very quietly. Zworykin demonstrated his electron multiplier tube to the I.R.E. in October; in November Armstrong gave his historic paper on frequency modulation.

1935-1940

The last five years telescope. The depression continues—at least everyone thinks so. Taxes increase tremendously, one does more business but makes less profit. Engineers still tramp from one factory to another. Manufacturers find it cheaper to hire engineers than mechanics and have less trouble with unions if they do so. Industry is still allergic to electron devices except where it cannot perform the desired functions in any better way. Welding continues to be the big electron tube application, 1000 ignitron welders had been placed in service by Westinghouse alone. Register control on printing presses, trimming machines and similar equipment is the bright phototube application. All during the 1930–1940 period continuous improvements were made in X-ray tubes. Power is still transmitted by ac, receivers cut off pretty sharp at 4000 cps or less; Armstrong insists that FM will solve the radio problem; but radio people say that no one wants better tone fidelity. Television comes out of the laboratory and goes on the air definitely and at much cost; a few receivers are sold; war comes to the world.

During 1936 Zworykin developed his electron telescope; Professor Mimno discovered that therapeutic machines were creating the mysterious long range havoc on communication channels; the beam power tube and the turnstile antenna appeared; Doherty worked out his high efficiency modulation circuits; Barrow and Southworth demonstrated hyper-frequency waveguides; R.C.A. put unattended repeater stations between New York and Philadelphia, operating a circuit on 100 Mc, feedback amplifiers became the plaything of engineers and college professors, following Black's earlier work; R.C.A. sold a high-fidelity Victrola. It was the year of the Magic Brain, the Magic Eye and the Magic Voice. Acoustic networks in radio sets gave some hope of higher fidelity.

During 1936 radio sets to the tune of 7.6 millions, $300 million were sold. Radios looked and sounded alike. The industry was settling down. Troublesome, however, was the talk about frequency modulation, television. New services, new schemes provided jobs for engineers but sales departments demanding something new all the time, didn't want anything *too* new. WQXR, broadcasting high quality record music in evening hours (1937), slowly gathered to its fold many thousands of New York's critical listeners tired of blah. Push-button tuning became the vogue, Philco demonstrated 441-line television, engineers squabbled over standards for television.

In August 1937 it was reported that fewer metal tubes were used in home receivers than the previous years, substitutes for metal tubes were invented. In August 1937 Don Fink began the construction of *Electronics* laboratory television receiver, described in a series of papers in 1938. The Engstrom-Holmes series of articles on the practical aspects of television receiver design and manufacture was published in 1938. Several new methods of attaining higher modulation efficiencies were described before the I.R.E. in 1938 and came into rather general use in the following years. The 1851–1852 high mutual conductance tubes appeared to aid television receivers. The highlight of the 1938 Fall Meeting was the Seeley-Foster television demonstration.

1938 and 1939 seemed to have been years of comparative quiet, if one is to judge by looking over the periodicals of that period. Television advanced slowly, N.B.C. bearing the burden of putting programs on the air. C.B.S. bought a transmitter but continued to make changes in it at the end of 1939. Armstrong put his Alpine W2XMN f-m transmitter on the air. Radio Engineering Laboratories built several transmitters for the Yankee network and others, several receivers were made ready for the market. The arguments of am vs. fm and of wide-band vs narrow-band fm became quite acrimonious and at the end of the year 1939 plans were made to reveal all at a meeting of the F.C.C. early in 1940. Improved pictures cross the Atlantic via R.C.A. and Western Union.

This review, admittedly brief and admittedly omitting many important events cannot end without some thoughts to the future. Electron tubes continue to go into industry slowly, but there is no revolution as was dreamed of 10 years ago. Broadcast stations continue to fill the air with drivel—and then by contrast to give us the Metropolitan Opera, the Toscanini broadcasts, the Philharmonic. Mae West and Orson Welles have served their purpose. Europe and Asia at war, America continues to be the land of the free and the continent of hope. Radio has settled down; broadcasting is a necessary part of the national life. Seeing as well as hearing is on the way, even if slowly.

Continued research and development into apparatus for the ultra-high frequencies point toward a vastly increased communication service in the microwaves.

Motions of electrons under control continue to offer much to man; who can guess what another 10 years will bring?

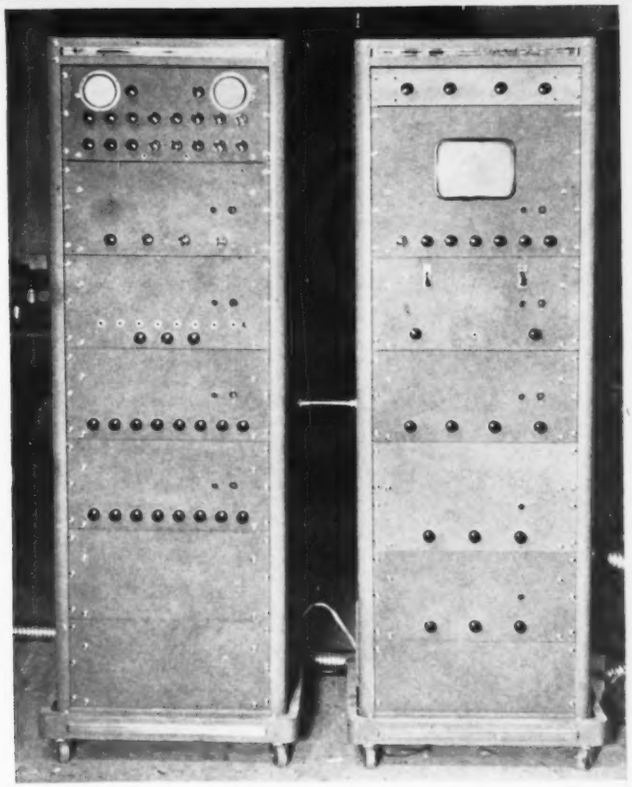


Fig. 1—Front and rear views of the rack assemblies. These chasses contain the complete equipment with the exception of the camera and the preamplifier which is mounted in the camera housing. The generator and auxiliaries contain 157 tubes in all

A Picture Signal Generator—I

First of a series of articles containing complete design data and circuits required for the generation of the standard R.M.A. T-111 video signal, including camera, sync signal generator, mixing, shading and keystone circuits, monitor, r-f modulator and receiver

By M. P. WILDER and J. A. BRUSTMAN

American Television Corporation

As the public interest and commercial activity in television broadcasting increase, more and more manufacturing organizations in the radio field are faced with the problem of developing the necessary engineering facilities to allow the design and development of suitable transmitting and receiving equipment. The central feature of these engineering facilities is a generator of the standard video signal, which provides a signal waveform similar to that which modulates the carrier of the television transmitter. Such a generator was required by the American Television Corporation as a source of standard picture signal for general receiver development and testing, as well as for the development of a television service for hotels, department stores, and hospitals. The latter purposes made necessary a highly compact and semiportable unit, including a camera which could be operated some distance from the generator itself.

This equipment is to be described in a series of articles, of which this is the first, in sufficient detail to make possible its duplication by readers who may wish to do so. The equipment is of necessity complicated—there are over 150 tubes in the generator all told—and it is quite possible that few readers will have the opportunity or need of building the complete unit. However, the design and construction of a standard picture signal generator involves virtually every function in television engineering. Thus the reader, who wishes to know how a certain function is performed, or to construct a unit capable of performing that particular function, may find useful information in these articles.

The front and rear views of the generator, complete except for the camera, are shown in Fig. 1. Standard rack-and-panel assemblies are used. The panels at the left (front view) contain the following items of equipment, from top to bottom: oscilloscope for viewing the signal waveforms; sync signal shaping unit; sync signal timing unit; iconoscope

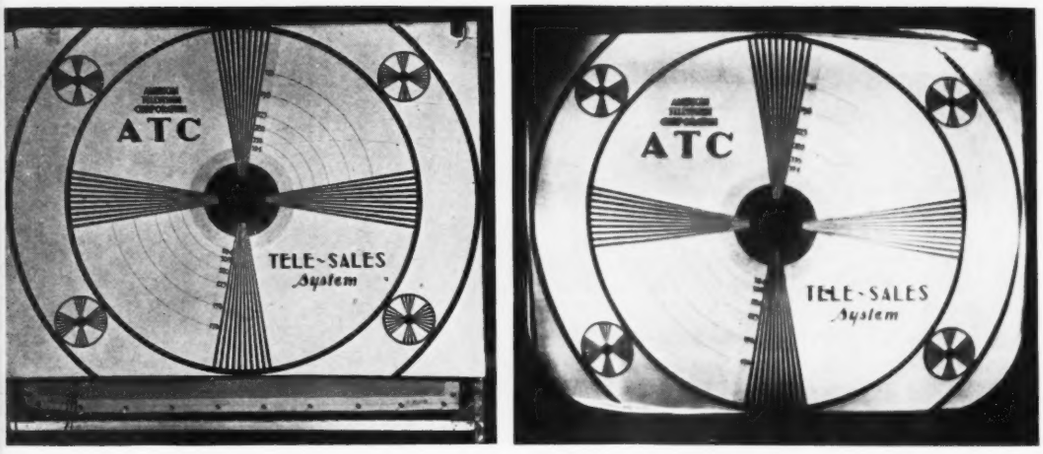
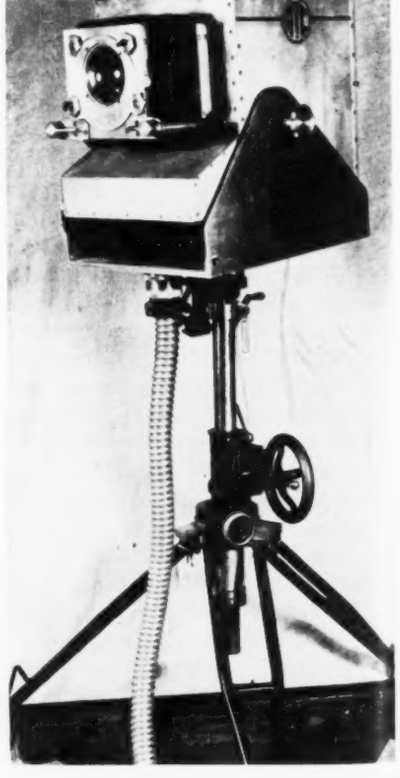


Fig. 2—Left, the performance of the generator as revealed by a test chart, original at the left, reproduction at the right. The horizontal resolution of the reproduction exceeds 450 lines (effective frequency range above 4.5 Mc). The interlacing is free of any observable instability

Fig. 3—Below, the camera. The view from the rear with cover removed shows the iconoscope camera tube and the wire shield



sweep circuits; the shading-correction signal generator; and at the bottom two regulated power supplies. The rack at the right includes a 4-channel television receiver (sight and sound); the 9-inch monitor picture tube and controls; line amplifier; mixing amplifier (which combines the camera signal, sync signals and blanking signals); two regulated power supplies; and at the bottom the sound output channel, and the picture and sound r-f channels.

The performance of the equipment (which operates with the standard R.M.A. 441-line T-111 type of signal, but is flexible enough to allow considerable variation from this standard if necessary) may best be judged from a test pattern, as shown in Fig. 2. The most critical aspect of performance is the horizontal resolution, which exceeds 450 lines. This considerably exceeds the performance capabilities of present-day television transmitters, and is in fact in excess of the maximum resolution which may be transmitted within the R.M.A. ether channel. The video amplifiers are in general flat to 4.5 or 5 Mc, overall, whereas the maximum required frequency for modulation is about 4 Mc.

Functions of the various parts

The basic power for the critical units is supplied by five electronically-regulated power supplies (one example of which is shown in Fig. 5), each capable of delivering 280 volts dc, with an internal resistance of one-quarter ohm. Four other conventional sources of power for the oscilloscope, monitor and iconoscope sweep circuits and the television receiver are also provided. The high voltage sources include 7500 volts for the monitor, 1200 volts for the iconoscope, and 1000 volts for the oscilloscope. This is a rather forbidding array of power supplies, but little is saved by trying to consolidate them, and much is gained in flexibility and freedom from circuit interaction.

The timer and shaper units produce the synchronizing pulses in accordance with the R.M.A. recommendations (441 lines 60 fields per second). These, with blanking impulses generated in the same units, are fed to a mixing amplifier which accepts also the output of the camera preamplifier. The mixed video signal is then amplified in a line amplifier, applied to the monitor tube and oscilloscope (the oscilloscope may be connected to any portion of the generating circuits by a plug connection) and used to modulate an r-f oscillator for r-f and i-f testing. Pulses from the synchronization signal generator are available for synchronizing any external equipment, such as remote Kinet viewing-screens in hotel rooms.

To cancel the spurious shading signal generated in the iconoscope, a shading-correction generator produces sine, parabolic, and sawtooth waves at 60 and 13,230 cps, of variable amplitude and capable of being shifted in phase through 360 degrees. The deflection of the scanning beam in the iconoscope is accomplished with conventional blocking-discharge oscillators and amplifiers. Trapezium distortion (arising from the oblique scanning of the mosaic plate in the iconoscope) is corrected in the horizontal iconoscope sweep circuits. The monitor picture tube is of the short 9-inch variety which gives sharp focus,

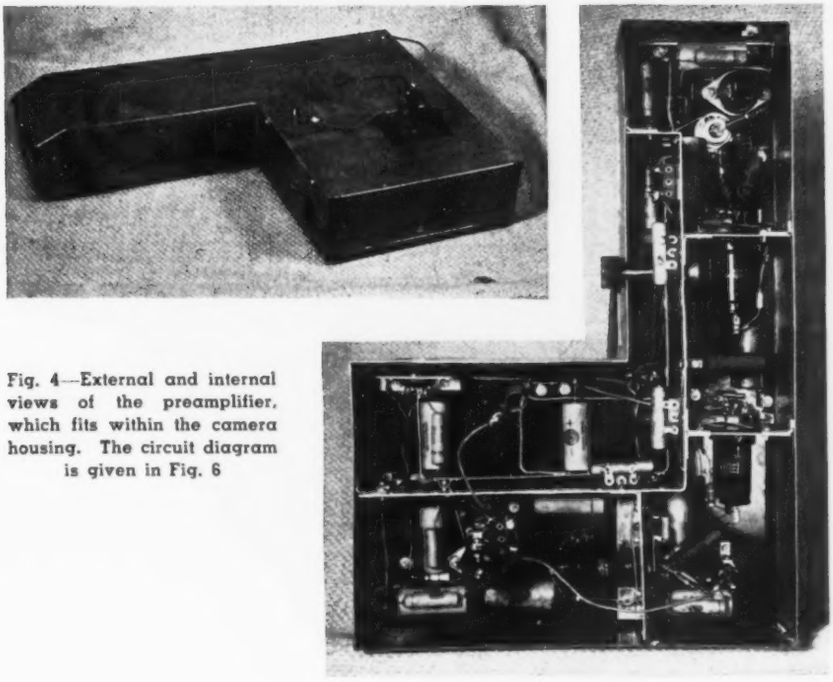


Fig. 4—External and internal views of the preamplifier, which fits within the camera housing. The circuit diagram is given in Fig. 6

and is relatively free from ion blemishes since magnetic focusing and deflection are employed. A four-channel receiver is provided to permit comparisons with the generator output, as well as to provide a source of program when the generator is used as a signal source in hotels, stores and the like. The operation of the completed generator has been found satisfactory in all respects.

In the description that follows, the equipment is arranged in logical order, i.e. the present installment describes the camera, preamplifier, and the auxiliary iconoscope power supplies and sweep circuits. The order in which the various units are constructed in practice may not follow this logical order (for example an oscilloscope should be available before the performance of the preamplifier can be judged accurately) but the usual laboratory test equipment (including an oscilloscope, i-f and r-f signal generator, vacuum tube voltmeter, and beat frequency oscillator) is sufficient to test each item of equipment as it is built.

Camera and Preamplifier

The camera, shown in Fig. 3, contains the iconoscope and preamplifier housed in an aluminum shield which also serves as the camera housing. An f/3 lens of 24 cms focal length is used. The preamplifier (Fig. 4) is based after the design of Allen Barco[1] of the RCA License Laboratory.

This amplifier employs a degenerative cathode-coupled first stage to reduce the effect of input capacitance of the grid circuit by a factor $1/(1+g_mR)$ where R is the cathode resistance and g_m is the transconductance of the first tube. A shield made of wire fitted around the bulb of the iconoscope further reduces the input capacitance. The complete circuit is shown in Fig. 6.

The effective input resistance in the first video stage is about 300,000 ohms, due to the effect of the degenerative current flowing through the 750-ohm cathode resistor. This high value of resistance results in a more favorable signal-to-noise ratio, since the thermal noise varies as the square root of the resistance, whereas the signal voltage varies (within limits) with the first power of the resistance. The signal voltage at high frequencies, however, is limited almost entirely by the shunt capacitance associated with this resistance. In the circuit shown, the effective shunt capacitance has been reduced to 8$\mu\mu$f. The combination of 300,000-ohm resistance and 8-$\mu\mu$f capacitance results in high generated signal through most of the video range, but the high frequencies are attenuated. The high frequency loss is compensated in the third stage, which has a peaked response in the high frequency region. The second stage is a straightforward shunt-peaked video amplifier.

The third stage is the high-frequency compensating stage. Barco shows that if the load impedance is of the series form $R + j\,w\,M$ and the magnitudes of R and M are properly related to the input resistance and

[1] Barco, A. "An Iconoscope Preamplifier", *RCA Review*, 4 (1), 89 (July 1939). Fink, D. G. "Principles of Television Engineering", McGraw-Hill Book Co., New York, 1940, page 394.

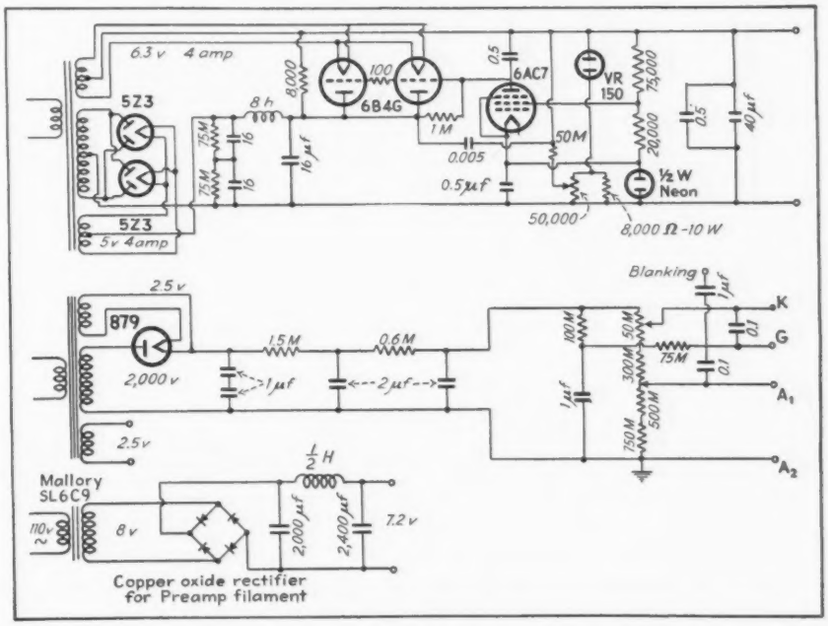


Fig. 5—Circuit diagram of the high-voltage and regulated low-voltage power supplies for the iconoscope, sweeps, and preamplifier

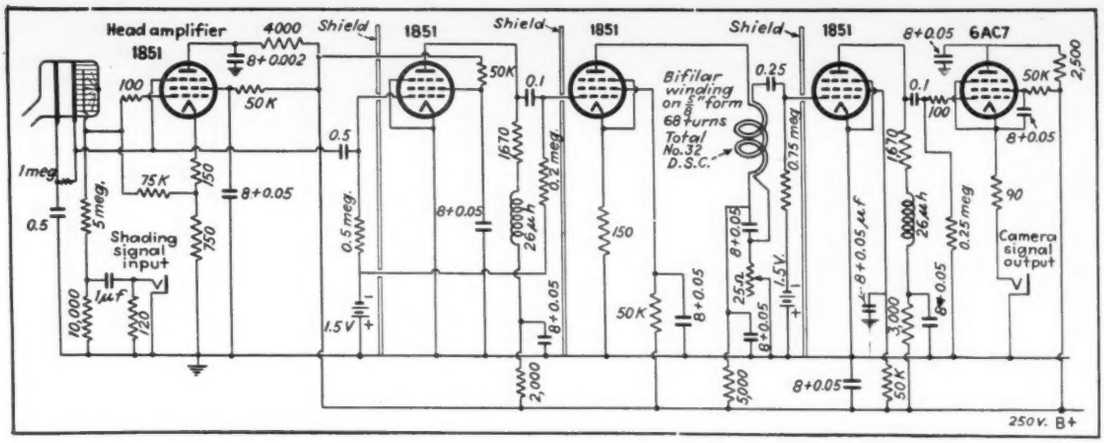


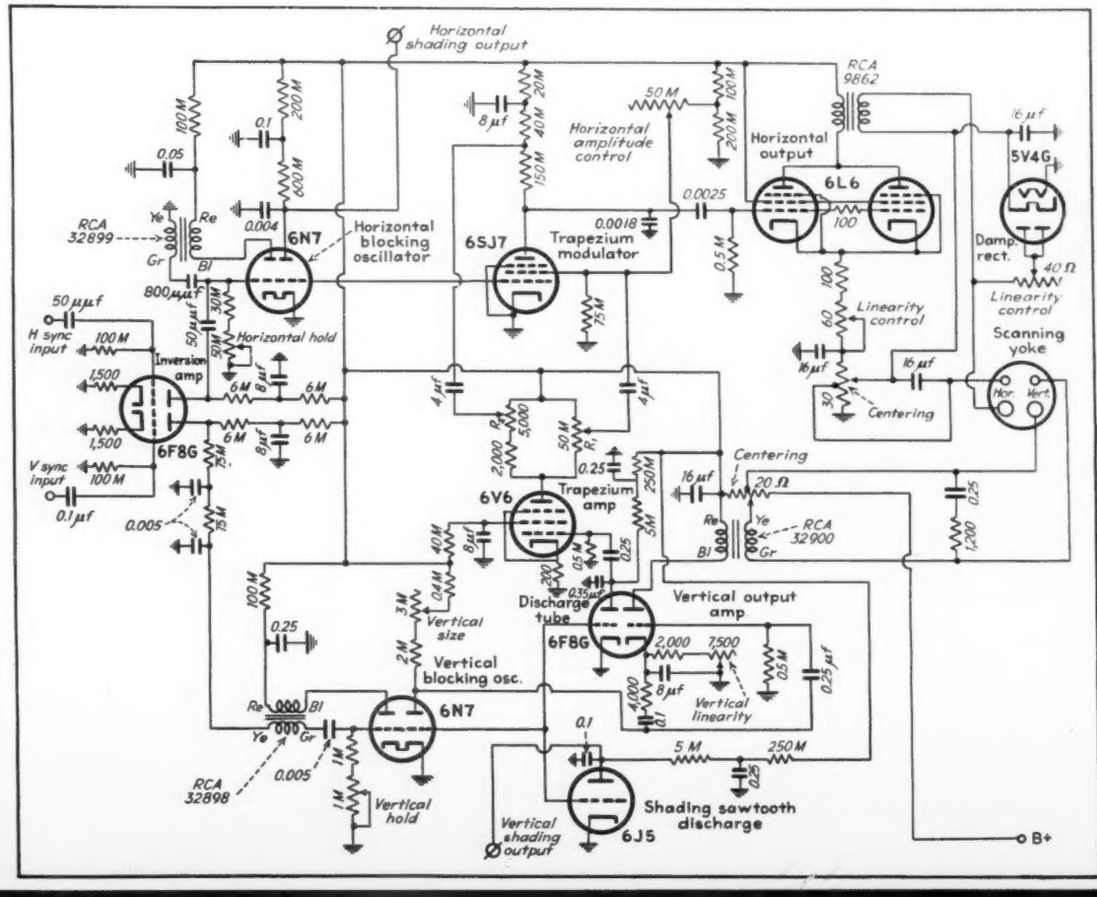
Fig. 6—Circuit diagram of the preamplifier which brings the iconoscope output voltage up to 0.1 volt, while maintaining an overall flat response to 5 Mc

capacitance at the first stage, the response will be of constant amplitude and of linear phase shift through the video band. The resistance *R*, in the plate of the third stage, is made variable and is adjusted for the optimum value by observing the image in the monitor picture tube. A very wide range of compensation is made possible by this arrangement. The gain ratio at low and high frequencies at the output of the first stage is about 400-to-8 whereas the compensation introduced in the third stage is about 8-to-400. The fourth stage is conventional, except that a somewhat larger than normal load resistance is used because the stage is followed by a cathode-follower stage whose input capacitance is lower than normal. The final stage is cathode-coupled to offer a low impendance (about 65 ohms) output.

The construction of the preamplifier is shown in Fig. 4. The first stage appears in the lower left hand corner, and is followed in order by the others. The variable load resistance in the third stage is arranged for external adjustment. The bifilar coil in the third stage may be seen just above the third type 1851 tube. The tubes should be mounted with pins 2 and 7 in a vertical plane to minimize sagging of the grid wires and consequent grid-to-cathode shorts. The amplifier is mounted on bakelite, fitted with the shields and then slipped into the L-shaped case and cover.

Power for the preamplifier is obtained from the electronically-regulated power supply shown in Fig. 5. The heaters of the preamplifier tubes are heated from a 7.5-volt copper-oxide rectifier equipped with a pi-type filter. This d-c heating current materially lowered the hum introduced in the amplifier, and at the same time a convenient source of current for the two bias lights was provided. The bias lights consist of two flashlight lamps which illuminate the interior of the iconoscope from the rear (no light must fall on the back of the mosaic plate, however). The bias lighting materially improves the shading difficulties and hence permits higher contrast in the picture. The bias lighting must be

Fig. 7—Circuit diagram of the iconoscope sweep circuits and the horizontal and vertical shading source



produced with well-filtered direct current. Two strips of scotch tape (visible in Fig. 3) are used to shield the mosaic plate from the bias lights. The iconoscope heater is fed from alternating current. The high voltage supply for the iconoscope must be well filtered, as shown in Fig. 5.

The Iconoscope Sweep Circuits

The connection diagram of the iconoscope sweep circuits is shown in Fig. 7. Several distinct functions have been incorporated in this unit. In the first place, two input terminals are provided to receive the horizontal (13,230 cps) and vertical (60 cps) sync pulses from the synchronization signal generator. The 6F8G double triode tube (at left in the diagram) reverses the phase of these signals. The outputs of these triodes may be used in either of two ways. They may drive the blocking oscillators (6N7 tubes above and below, next to the right), or they may be connected directly to the output amplifiers (2-6L6's for the horizontal scanning, one section of a 6F8G for the vertical). The 6SJ7 tube (top center) is used to introduce the trapezium correction. The vertical sawtooth waves from the 6V6 stage are applied through resistors R_1 and R_2 to the plate and screen of the 6SJ7 modulator tube amplifier. The modulator tube in turn modulates the amplitude of the horizontal sawtooth wave at the vertical sawtooth frequency. This assures wider scanning at the bottom of the mosaic plate than at the top, which compensates for the oblique angle of scanning. The resistors R_1 and R_2 are adjusted while viewing the picture on the monitor until the image (which has a trapezoidal shape in the absence of the modulation) assumes a true rectangular shape. R_1 controls the balance of the correction on either side of the pattern and R_2 controls the amount of compensation.

The horizontal output amplifier is conventional, including a distribution (waveshape) control and centering control in the cathode. The 5V4G is the usual damping tube required to damp the residual oscillation at the base of the sawtooth current impulses.

A separate shading discharge tube (6J5) is used to develop the vertical sawtooth for vertical shading correction, from the blocking oscillator. The horizontal shading output is taken directly from the horizontal blocking oscillator. These shading voltages are used to control the shading generator. The sine wave and parabolic shading waves are derived from them in circuits to be described later.

Three separate discharge tubes are used following the vertical blocking oscillator: one for the deflection system, one for the trapezium correction, and one for the sawtooth shading signal output.

The Deflection Yoke

The deflection yoke for the iconoscope is shown in Figs. 8 and 9. It consists of two vertical coils in series and two horizontal coils in series, arranged on axes at right angles to the tube axis. The vertical coils consist of 540 turns each, number 28 enameled wire. Each coil is wound in six "pies" or groups of turns of 90 turns each. The dimensions of the winding jig are shown in Fig. 8. The pie sections are kept separate by pins separated $\frac{3}{16}$ of an inch apart as shown in the sketch.

The horizontal coils are wound in a single group of 90 turns, of number 26 enameled silk wire. The thickness of the coil is 0.036 inch. The coils are then formed on a cylindrical mandrel $1\frac{3}{8}$ inch in diameter. The long dimension of each coil is parallel to the axis of the mandrel. The turns on the end of the horizontal coils are bent sharply backward away from the axis of the yoke. The coils are assembled on a bakelite tube insulated with empire cloth, cemented with ambroid cement (wax impregnation is not used), and the whole structure is then wound with three layers of number 26 oxidized and annealed steel wire. Two layers of 0.005-inch thick soft iron sheet also serve satisfactorily.

The timer and shaping unit of the synchronization signal generator will be described in the next installment.

The authors wish to express their appreciation to Messrs. Martin, Schiesel, Ekstrand and Shulz for their assistance in constructing the unit and for their many helpful suggestions in its design. They also wish to express their appreciation to Mr. Beverly Dudley of *Electronics* and *Photo Technique* for his excellent photographs of the apparatus.

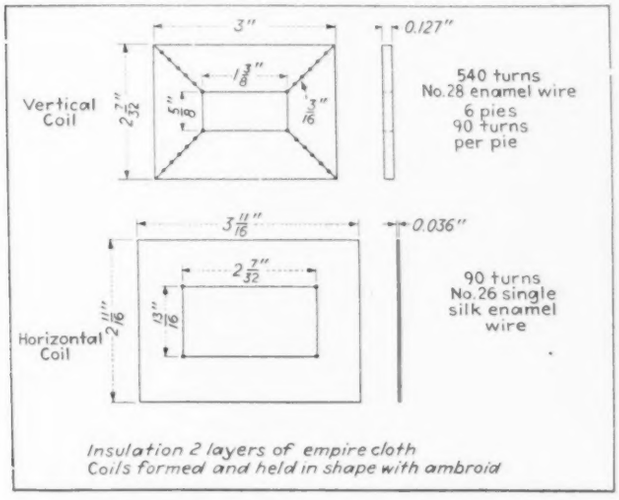


Fig. 8—Dimensions of the jigs on which the horizontal and vertical deflecting coils are wound. The vertical coils are wound in six pies, separated by the pins on the jig

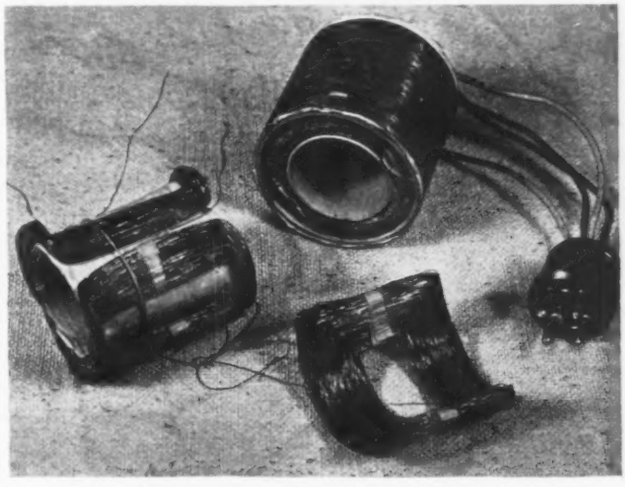
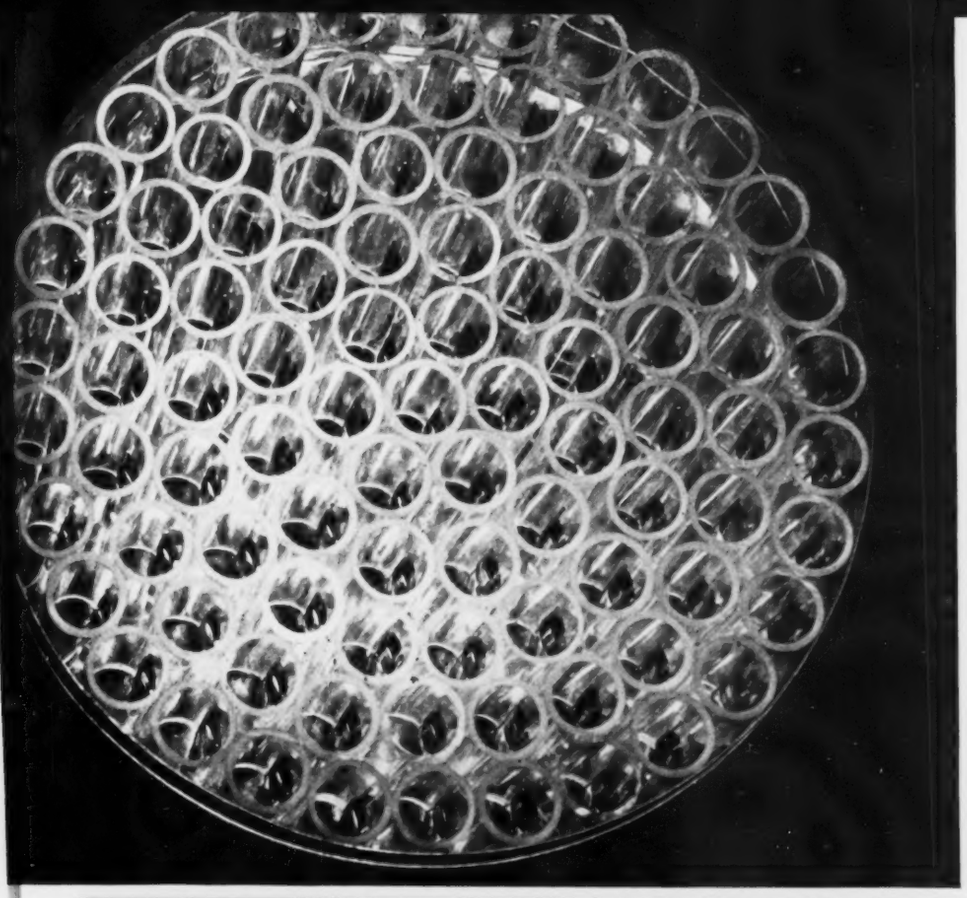


Fig. 9—The iconoscope deflecting yoke. The coils are wound in a flat plane, then formed on a cylinder, cemented, insulated, and wrapped with soft iron wire

"D-157654"—a Megacycle Repeater

A new Western Electric repeater tube for wideband coaxial circuits, which packs plenty of g_m into a small space

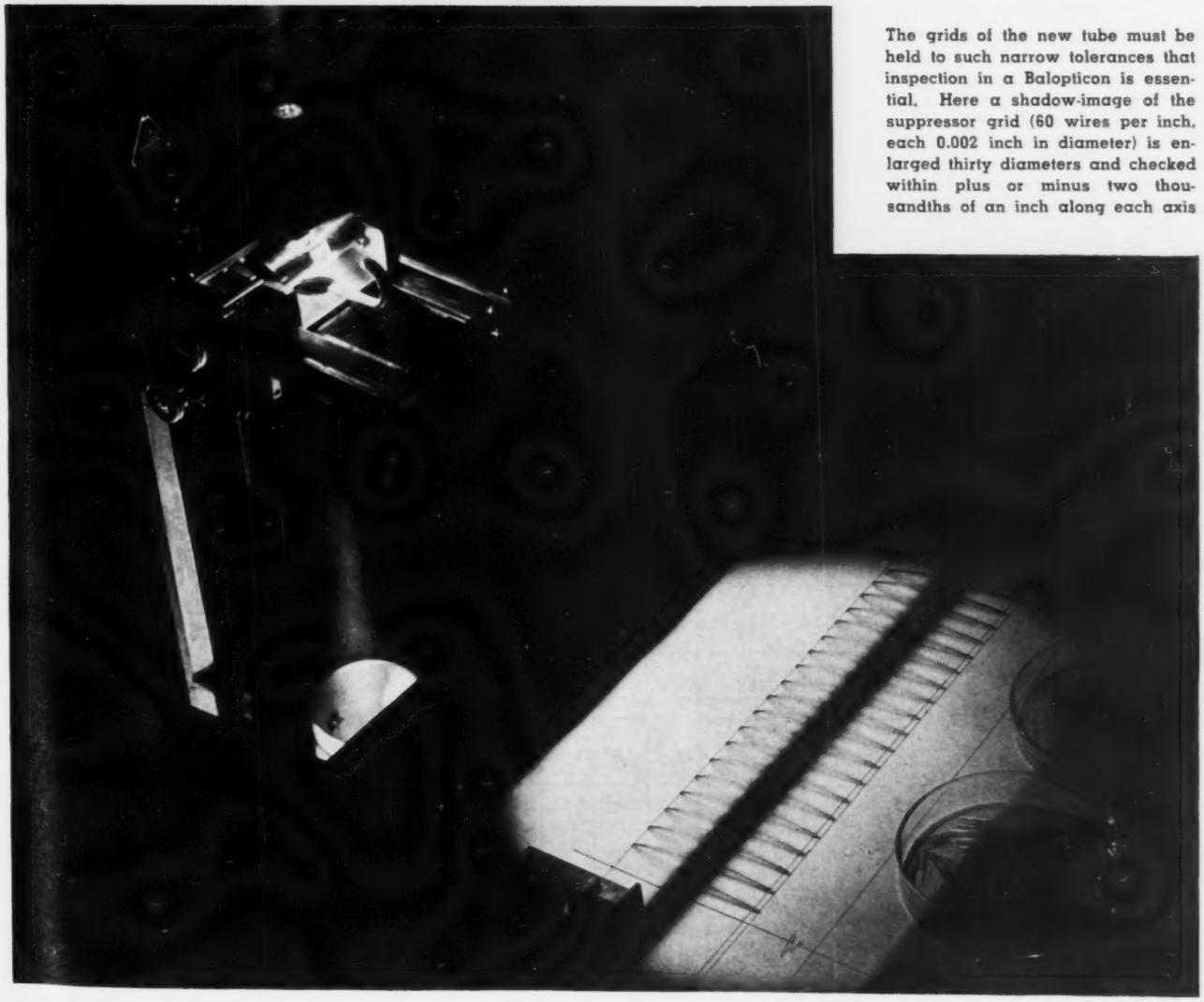


Upper left, the new tube is a pentode with a g_m value of 2600 micromhos, and a sum of input and output capacitance of 5.2 $\mu\mu$f. Its figure of merit for wideband service is accordingly over 500, which puts it in a class by itself

Upper right, the control grids are perhaps the most delicate ever put into a vacuum tube: 200 turns per inch, of wire 0.001 inch in diameter. Each grid before assembly is handled in a separate cylinder of glass, and packed in the container shown above. The whole set-up looks something like the 200-inch Mt. Palomar telescope mirror in miniature

Lower left, the girls who mount the elements must have the manual dexterity of a jeweler, but once this adeptness is acquired, the time required for completing the mount is not much longer than in more conventional tubes. Here the elements are mounted on the support micas and welded to the stem

The grids of the new tube must be held to such narrow tolerances that inspection in a Balopticon is essential. Here a shadow-image of the suppressor grid (60 wires per inch, each 0.002 inch in diameter) is enlarged thirty diameters and checked within plus or minus two thousandths of an inch along each axis



The COAXIAL LOUDSPEAKER

A high-frequency speaker, nested within the cone of the low-frequency unit and protected from the low-frequency acoustic output. The combination has excellent frequency range, low distortion, wide-angle distribution, while offering a single localized source of sound

By BENJAMIN OLNEY
Stromberg-Carlson Telephone Manufacturing Co.

INTEREST in loudspeakers of wide frequency range has been heightened by the recent advent of radio transmission systems which are not subject to the usual audio frequency band width limitations. Frequency modulation systems in particular offer the possibility of reception up to the highest audible frequencies together with a large increase in signal to noise ratio. While extended frequency range loud speakers have been available for some years past, their full possibilities could not generally be realized in radio receivers, chiefly because of the increase in reproduced noice resulting from the widening of the frequency band. It is believed that the noise-reduction feature of the frequency modulation system together with its low non-linear distortion makes practical for the first time the utilization of the full audible range in broadcasting.

Advantages of Dual System

The loudspeaker system to be described was designed to be housed in a console radio receiver of moderate size. It is of the dual type employing separate dynamic cone loudspeakers for the high and low frequency ranges, and each speaker is fed its appropriate frequency band through a common dividing network of the four element, constant resistance type. Its effective frequency range is from below 65 cps to above 10,000 cps.

The well known and outstanding advantage of the dual system is that each of its loudspeakers may be designed specifically for its own restricted frequency range, thus overcoming to a large extent the limitations imposed by the inherent design conflict between frequency range and power handling capacity. There are other advantages, however, that merit consideration. First, the onset of beam radiation may be postponed to a higher frequency and the directional characteristic in general may be much improved by taking advantage of the greater freedom of choice afforded in the size of the radiators to make the diameter of the high frequency cone as small as possible. Second, it is known that most cone-type, moving-coil loud speakers are somewhat non-linear at large amplitudes. The resulting distortion of low frequency waves alone is usually not unpleasant to the ear. However, when such a loudspeaker is supplied with a complex input signal comprising components of low-frequency and large amplitude together with high frequencies, the high frequencies are modulated by the low frequencies and an aurally unpleasant form of

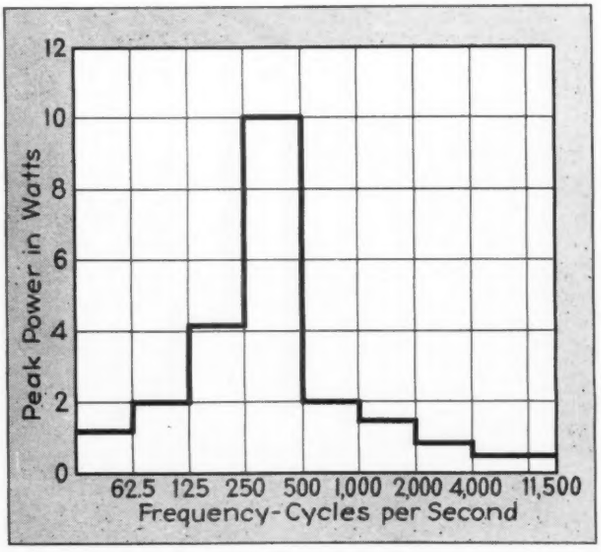


Fig. 1—Peak powers delivered by an orchestra within various frequency regions (after Wente and Thuras)

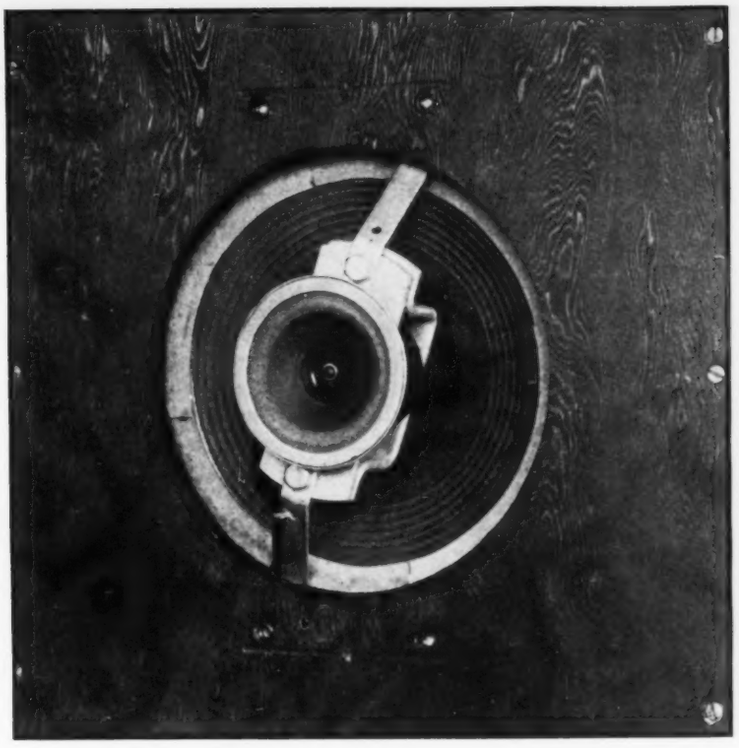


Fig. 2—Photograph of coaxial dual loudspeakers viewed from front of baffle

distortion results. Such effects are much reduced in dual systems because the restricted frequency range of the low frequency speaker curtails the modulation possibilities.

Choice of Cross-over Frequency

It is possible by careful design to produce a cone type low frequency loudspeaker of moderate size that will afford a mid-range response substantially flat up to about 1500 cps and falling off above that frequency. Also, to obtain a smooth response and wide angular distribution requires that the high frequency speaker cone be small, which restricts its power handling capacity because of amplitude considerations. As the power delivered by musical instruments is much smaller in the higher than in the lower frequency bands, it appears logical to take full advantage of the flat response range of the low frequency speaker and fix the cross-over frequency at 1500 cps. Then we may design the high frequency speaker with the smallest cone capable of handling the expected maximum input power at feasible amplitudes. That a 1500 cps cross-over frequency also is advantageous with respect to the power handling capacity required in the high frequency speaker will be appreciated upon inspection of Fig. 1, derived from the original data of Sivian, Dunn and White[1] by Wente and Thuras[2]. It will be seen that a higher cross-over frequency would not greatly reduce the requirements, while a substantially lower cross-over might increase them nearly tenfold. The fact that the chosen cross-over frequency is located in the midst of the important speech frequency range is a disadvantage in ordinary designs, but this difficulty is overcome in the present system in a manner which will be described later.

Construction of the Speakers

The low frequency loudspeaker has an 8-inch diameter cone and is provided with a large and powerful field magnet. A ribbed, moulded fiber cone of unusual rigidity is used, and is fitted with an edge suspension of carpincho leather. The leather edge was found necessary to suppress strong peaks above the cross-over frequency which otherwise would have overcome the attenuation of the dividing network. The back of the cone works into a labyrinth[3], enabling this moderate sized speaker to handle comparatively large input powers at low frequencies and to radiate these low frequencies effectively and without undesirable resonances.

The moulded fiber cone of the high-frequency loudspeaker is only 2½ inches in diameter. It is driven by a very light aluminum coil in a 12500 gauss field and has an edge suspension of carpincho leather. The latter was found essential for securing smooth response and adequate power handling capacity. Edge damping plays an important role in small cone structures because, over the frequency range wherein flexural waves are propagated through the diaphragm, large amounts of vibratory energy reach the edge over the comparatively short radial paths. At these high frequencies the leather affords strong damping, preventing excessive reflection and the development of sharp cone resonances.

The center suspension consists of a thin disc of hard aluminum alloy having a moderate degree of stiffness. Low damping is an essential requirement in this suspension as any mechanical resistance therein is directly effective in reducing the vibratory energy available for driving the cone. Substitution of a disc of the usual fibrous material causes a noticeable loss in efficiency.

The back of the high frequency cone is tightly enclosed by its supporting pan. This enclosure has three important functions. First, the air enclosed within it provides an acoustic stiffness so proportioned as to resonate broadly the mass of the moving system near the lower end of the high frequency band. The resulting increase in diaphragm velocity just offsets the falling off of radiation resistance with decreasing frequency which sets in at about 2500 cps for a 2½-inch diaphragm. The response is thus maintained substantially uniform down to about 1500 cps.

Another function of the acoustic stiffness created by the back enclosure is to protect the moving system of the high frequency speaker against damaging amplitudes due to extreme sound pressures set up by the closely adjacent low frequency speaker. Since high pressures are normally associated only with sounds whose frequencies are far below the resonance frequency of the high frequency speaker, the diaphragm of the latter presents a very high im-

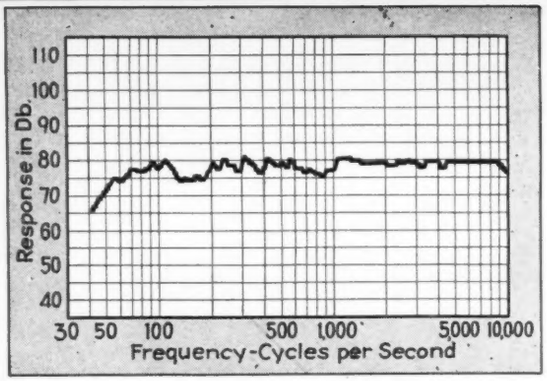


Fig. 3—Overall frequency characteristic of a frequency modulation transmitter, receiver, and coaxial loudspeaker system. Acoustic measurements made with a rotating microphone at 10 feet average distance

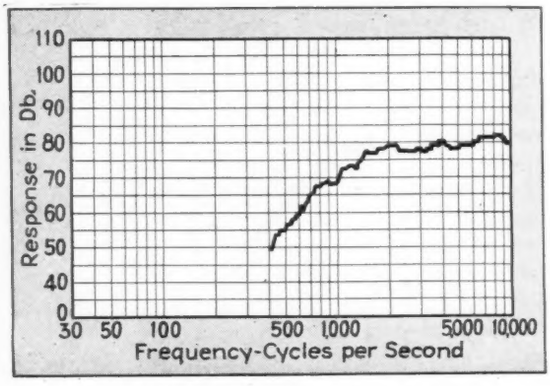


Fig. 4—Response of a high frequency loudspeaker alone at 18-inches distance on axis

pedance to such external driving. As both this driving pressure and that opposing it are distributed uniformly over opposite faces of the diaphragm, no deforming forces are exerted upon the latter. Such would not be the case, however, were the entire protective stiffness located, for example, in the cone center suspension. In addition to the possibility of damage, acoustic driving of the high frequency diaphragm at wide amplitudes by the low frequency speaker would very likely result in undesirable modulation.

The third function of the closed back is to provide a baffle for the high frequency speaker, this being necessary because of the unusual mounting arrangement described in the next section.

Mounting of Speakers

The high frequency speaker is mounted coaxially with the low frequency speaker and as far as possible within the hollow of its cone (see Fig. 2). This arrangement was adopted as the result of listening comparisons with a single loudspeaker of somewhat wider than usual frequency range. Although, according to measurements, the dual system with its speakers mounted in the usual side-by-side relationship had a wider and smoother response than did that of a single speaker, the latter appeared to give much more natural reproduction, especially of speech, where facilities were available for direct comparison with the original. When the coaxial arrangement of speakers in the dual system was tried, however, there was an immediate reversal in the results of the tests, the dual system now being found preferable to the single speaker. The superiority of the coaxial arrangement was verified by further listening tests on a dual system where the coaxial high frequency speaker was switched against another identical one mounted in the usual location beside the low frequency speaker.

Although the differences observed in the above tests were subtle and difficult of analysis, listener preference for the coaxial arrangement was quite positive. The following is offered in explanation of the audible differences. First, it is a commonly observed fact in making listening tests that one has little difficulty in detecting which of two similar side-by-side loudspeakers is operating even when the two are located as close together as possible in the same baffle. This happens even at listening distances at which the reflected sound from walls, etc., may equal or exceed that arriving at the ears directly from the loudspeakers and is an illustration of the discrimination afforded by the binaural hearing sense. The same effect can exist with side-by-side speakers in a dual system, particularly when the frequency division is made at about the middle of the important frequency range, or higher and results in the impression of a divided sound source. Speech is more seriously affected than is music, probably because one intuitively expects speech to come from a single small source and is disturbed when the source appears to be a multiple or an extended one.

A second defect of side-by-side dual systems may reside in the possibility of phase distortion in the reproduction of transients at the listening position, arising from the spaced relationship of the loudspeakers. While it is well recognized that the ear is insensitive to phase shift among the components of steady tones of moderate intensity, there is some reason to believe that the same is not generally true for transient sounds. The coaxial, nested arrangement of the high and low frequency speakers appears to simulate closely a unit source, thereby tending to reduce the above described distorting effects to practical insignificance.

The location of the high frequency loudspeaker in front of the low frequency cone raises the question of its possible obstructive effect upon the radiation from the latter. From a theoretical consideration of the radiation from an 8-inch piston and the diffraction around a sphere equivalent in volume to the high frequency speaker structure, it appears that the latter starts to become effective as an obstacle in the frequency region which also marks the beginning of directional radiation from the low frequency cone and which, furthermore, is not far below the crossover frequency of the system. The effectiveness of the obstacle is thus limited to a comparatively small frequency region within which measurements indicate that it acts desirably in offsetting the axial concentration which otherwise would take place.

Performance

The response curve shown in Fig. 3 is of particular interest, in that it is the directly measured overall characteristic of a complete frequency modulation system including a transmitter, a receiver and a loudspeaker system of the type described in this paper. The receiver with its loudspeaker system was a sample taken at random from production. The measurements were made with the aid of a fully automatic recording system which drew the graphs directly and whose audio oscillator was employed to modulate the frequency modulation transmitter. The receiver was located in a damped room and the sound was picked up by a rotating microphone which swept around an 8-foot diameter circle inclined at a vertical angle of 45 degrees to the speaker axis, and whose center was located at 10 feet distance on the latter. The recording system was provided with means for averaging the fluctuations in microphone output caused by standing waves in the measuring room and by the

varying distance from the loudspeakers. The curve shown is essentially the response curve of the loudspeakers, as separate measurements showed that the overall electrical characteristic of the remainder of the system was flat within 2 db.

Figure 4 shows the response of the high frequency speaker alone, measured with a stationary microphone located on the speaker axis at 18 inches distance. That the trend of this curve is not very greatly different from that of Fig. 3 above 1500 cps, indicates wide angle radiation. The difference between the curves of ordinary single cone speakers measured by the two methods mentioned is large at the high frequency end, there being invariably a pronounced droop in the rotating microphone curve. This is due to axial concentration of the radiation at high frequencies, it being recalled that the arrangement of the rotating microphone is such that the latter never crosses the axis of the loudspeaker but sweeps over an outer zone of radiation.

To show further the wide angle radiation characteristic of the coaxial-dual system, the results of comparison measurements with a single 8-inch cone speaker at 6000 cps are given in Fig. 5. There is a comparable difference at other high frequencies. These measurements were made on an 18-inch radius in a damped room, the frequency being held constant and the response recorded automatically as the microphone was moved slowly around its arc. The response is plotted in db relative to that on the axis.

It is believed that, in evaluating the performance of loudspeakers for the home, too little attention has been paid in the past to their directional radiation characteristics. Response measurements made on the axis alone are of very limited use in estimating the performance of loudspeakers under working conditions; in fact, they may be quite misleading. This was brought forcibly to our attention in making comparative measurements and listening tests between the coaxial-dual system and a single wide range loudspeaker whose cone size was the same as that of the low frequency speaker in the former system. Although a comparison of axial response measurements showed both to have a horizontal trend, to describe the difference on listening tests with the observer stationed first on the axis and then not more than about 30 degrees off impels us reluctantly to borrow from the vocabulary of the advertising man and designate the effect as startling. When listening to music containing percussion effects rich in high frequencies, the tambourine jingles, for example, nearly disappeared from the reproduction of the single speaker when the observer moved to the off-axis position while the reproduction of the dual system changed little between the two positions. Another effect resulting from the wider angle distribution of the dual system is the sensation of spatial perception or "presence", particularly when listening to large orchestras, which arises probably not only from the greater amount of high frequency radiation directly received by an observer in an average location but also from the greatly increased high frequency reverberation in the receiving room.

In general, the reproduction afforded by this dual system with its wide range, flat response appears to be highly natural. A rather unexpected effect is an apparent increase in dynamic range when compared with a single speaker of the same size, covering a similar frequency range, but having considerably less regularity of response and much greater directivity at high frequencies. The undistorted acoustic output of this dual system has appeared to many observers to be surprisingly high considering not only the cone sizes but also the size of the complete assembly. It can be housed in a cabinet whose inside dimensions are 25 inches high by 23 inches wide by 11 inches deep. The laboratory model has been used on a 20-watt amplifier for several months and the amplifier has frequently been driven to the threshold of overload on musical programs without damage to or noticeable distortion in the speaker system. On listening comparison with average single radio loudspeakers of similar size, the efficiency of the described system appears to be from 4 to 6 db higher.

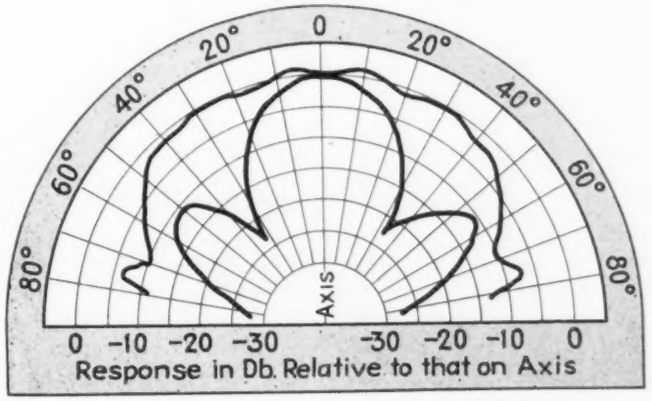


Fig. 5—Comparison of directional radiation at 6000 cps: outer curve, coaxial system; inner curve, single 8-inch speaker, both measured on 18-inch radius in horizontal plane

Microphones, Studio Practice and High Fidelity Reception

Although this article is concerned primarily with the description of a loudspeaker system, it is believed, in view of new problems that may be encountered, that some comments on microphones and studio technique should be added.

One certain conclusion is that broadcasting of the highest technical quality cannot consistently be maintained without the use of monitor loudspeakers known to possess a wide, flat frequency characteristic and located in a suitable acoustic environment. The importance of the monitor loudspeaker (together with the room in which it is heard) in determining what goes out on the air can hardly be over-emphasized. Used as it is for a guide in securing the best sounding arrangement of the performers before the microphone, its frequency characteristic becomes effectively inserted in the overall transmission system. It obviously is essential that the monitor loudspeaker equal or exceed in frequency range the best loudspeakers used in receivers, for otherwise certain types of distortion, undesired noises and unnatural effects may escape the attention of the monitoring

(*Continued on page* 106)

A PRACTICAL STROBOSCOPE CIRCUIT

Control unit for use with a conventional Cooper-Hewitt lamp, having a wide range of frequency as well as controlled duration of the light impulses, useful for industrial studies of high speed motion

By C. C. STREET

Chief Engineer, Federal Products Corp.

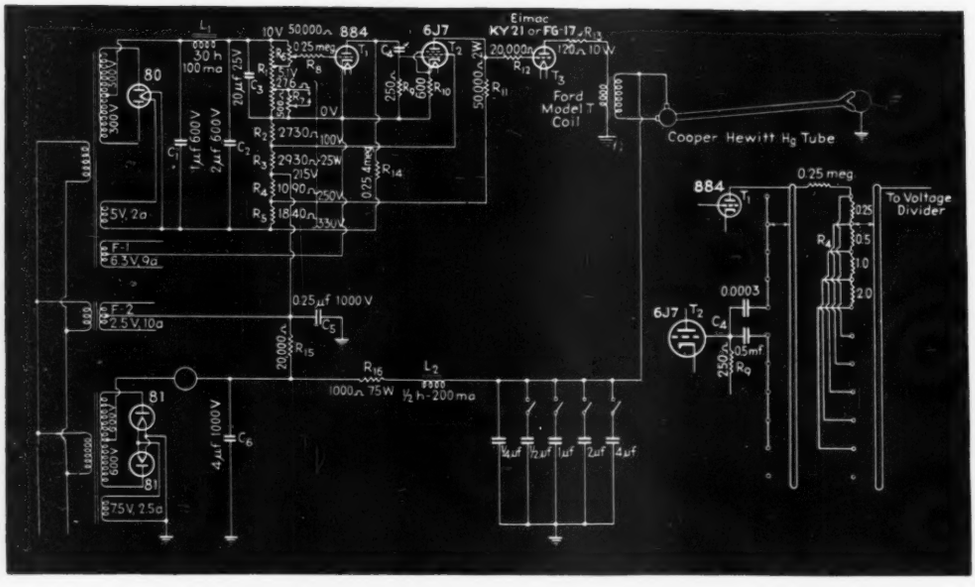


Fig. 1—Complete circuit diagram of the stroboscope. The insert diagram at the right shows push-button connection for varying the flashing rate

TO many experimenters the stroboscope has proved itself a remarkably useful instrument. Besides its conventional use on recurrent phenomena it can give much information about single-cycle transient conditions. By using a camera with a reasonably high speed lens and film sensitive to the spectrum of the illumination used, pictures may be taken of a single transient event by illuminating the object with the stroboscopic light while leaving the shutter open. This gives a series of super-imposed images, the spacing of which on the picture gives distance-time value from which velocity and acceleration curves may be drawn.

When relatively slow frequencies are to be observed such that the persistence of vision does not give a clear image, the camera again is of value. The author has made several microscopic pictures of small objects that operate at a frequency of 150 cycles per minute.

The instrument described here can be made to a large extent from parts that most experimenters in electronics have on hand. Except for the gaseous tubes all parts are commonly used in communication equipment. The instrument has its own timing circuit and can be made to flash at frequencies between 17 cycles and 18,000 cycles per minute.

The source of light is a Cooper-Hewitt mercury vapor lamp. There is no need of securing a new one since a tube that has been retired from regular illuminating service, because of difficulty in starting, will fire satisfactorily in this circuit. Such a tube was used in the instrument described.

There are two distinct portions of the circuit, a power supply and a timing circuit. The power supply shown will supply 800 volts to the condensers at about 170 ma. This amount of power is sufficient for average work, and it can be increased as desired for more intense illumination. The timing circuit is more critical and many systems were tried before arriving at the one shown.

An independent power supply was used for the timing circuit to eliminate as much as possible the surge affects that result if the main power unit is used. The timing itself is accomplished with a relaxation oscillator similar to the saw-tooth generator of a cathode ray oscilloscope. Condenser C_4 in the grid of T_2 is charged through R_{14} from the voltage divider, to a voltage determined by the grid bias of the 884 tube (T_1), minus the drop across T_1. This drop is constant during conduction at approximately 16 volts. The voltage developed across R_9 is applied to the grid of T_2, a 6J7. When T_1 is nonconducting during the charging cycle of C_4 the only bias on T_2 is produced by R_{10}. This is simply to limit the current through the tube to a reasonable value. During the discharge of C_4 through T_1 the grid of T_2 is carried negative well beyond cutoff and conduction ceases. The voltage developed across R_{11} is applied to the grid of T_3 and will keep that tube nonconducting. As T_2 goes beyond cutoff, the grid of T_3 goes 25 volts positive with respect to its cathode. This allows T_3 to ionize and discharge C_5 through the transformer. The sudden surge of current in the primary develops an extremely high

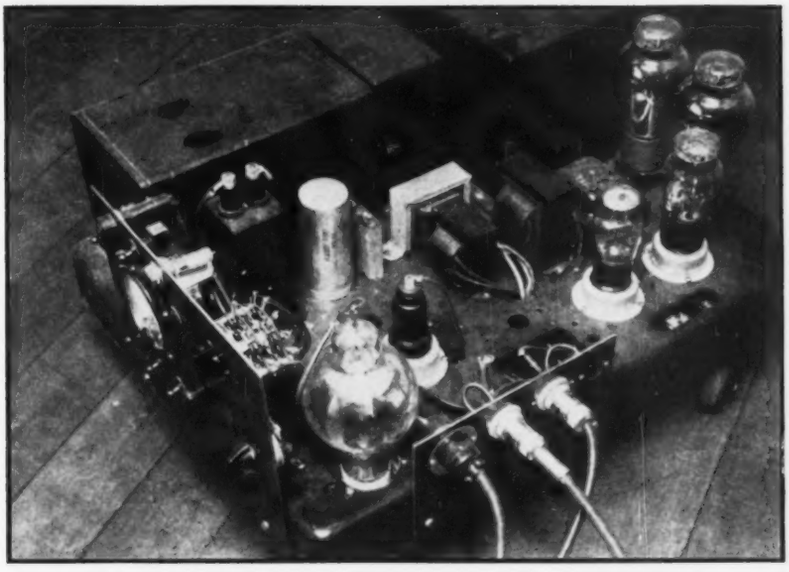


Fig. 2—Detail of chassis layout of control unit, showing discharge thyratron in foreground

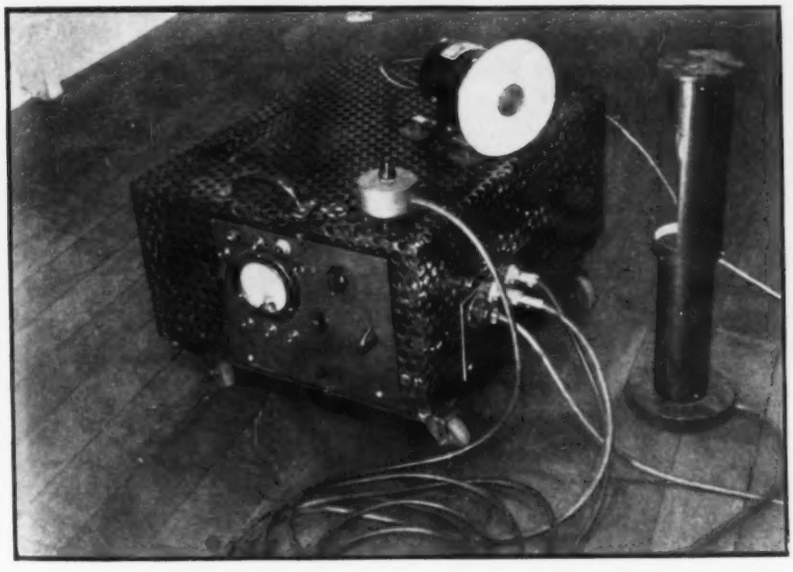


Fig. 3—Control with protective cover in place. Note control potentiometer and cable on top of cover

voltage in the secondary. This appears as an electrostatic potential between the mercury and shield of the Cooper-Hewitt tube. This high potential, in the neighborhood of 10,000 volts, ionizes the mercury vapor in its corner of the tube. As soon as free electrons are available, the power supply across the two ends of the tube, causes further ionization and the condenser bank discharges through the Cooper-Hewitt giving a brilliant light of extremely short duration.

For the grid of T_3 to regain control of the tube when C_5 is discharged, it must be negative soon after ionization is complete. For this reason the discharge time of C_4 must be held to a minimum, limited only by the ionization time of T_3. In most tubes of the FG-17 type ionization is complete in from 10 to 15 microseconds. The values shown will give a minimum discharge time for C_4 of 20 microseconds.

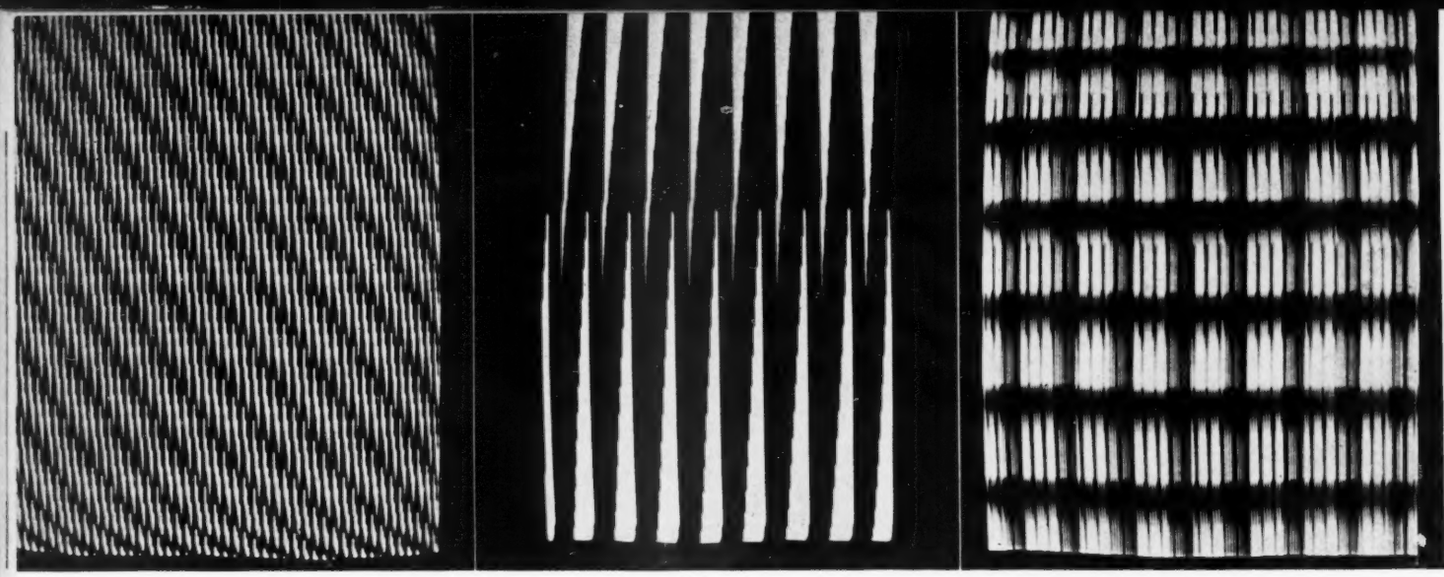
The potentiometer R_6 can be put at the end of a three wire cable and is used to control the speed of flash over a range of 2 to 1 for any setting of C_4 and R_{14}. The cable must be shielded or the stroboscope will flash at multiples of 60 cps due to external fields. R_7 is used as an external synchronizing device. The breaker points may be made from an old automobile distributor and driven at the speed at which the flashing is desired. If the amount of synchronization is kept low by having the breaker points short out only a small portion of R_7's resistance, any multiple or sub-multiple rate may be used. The layout of the chassis should be such that as little as possible of the magnetic fields of the transformers cut the two thyratrons. If desired magnetic shielding may be employed. If T_3 is exposed to a 60 cps the arc within the tube is "blown" back and forth as its timing passes in and out of phase when firing near fundamental frequency. R_{13} is used to limit the voltage in the secondary of the high tension coil. At low frequencies it is apt to spark across the exposed portion of the tube. The cable leads from the power supply to the mercury tube should be heavy. Any appreciable amount of resistance here will lengthen the duration of the flash and reduce its brilliancy. R_{15} and L_2 are used to keep C_5 from discharging through the mercury tube and allow its arc to be extinguished when the voltage of C_7 has fallen below the tube drop of approximately 75 volts.

If the high tension transformer is to be cased, it should be done with a non-conducting material such as bakelite or hard rubber since a metallic case will represent a shorted turn and impair correct operation.

The 0-300 milliampere meter is of value since it allows a check on the power load which must not exceed the rated value of the rectifier tubes. Portions of the condenser bank may be cut out as the frequency increases. At high frequencies the persistence of vision allows easy observation at reduced brilliance.

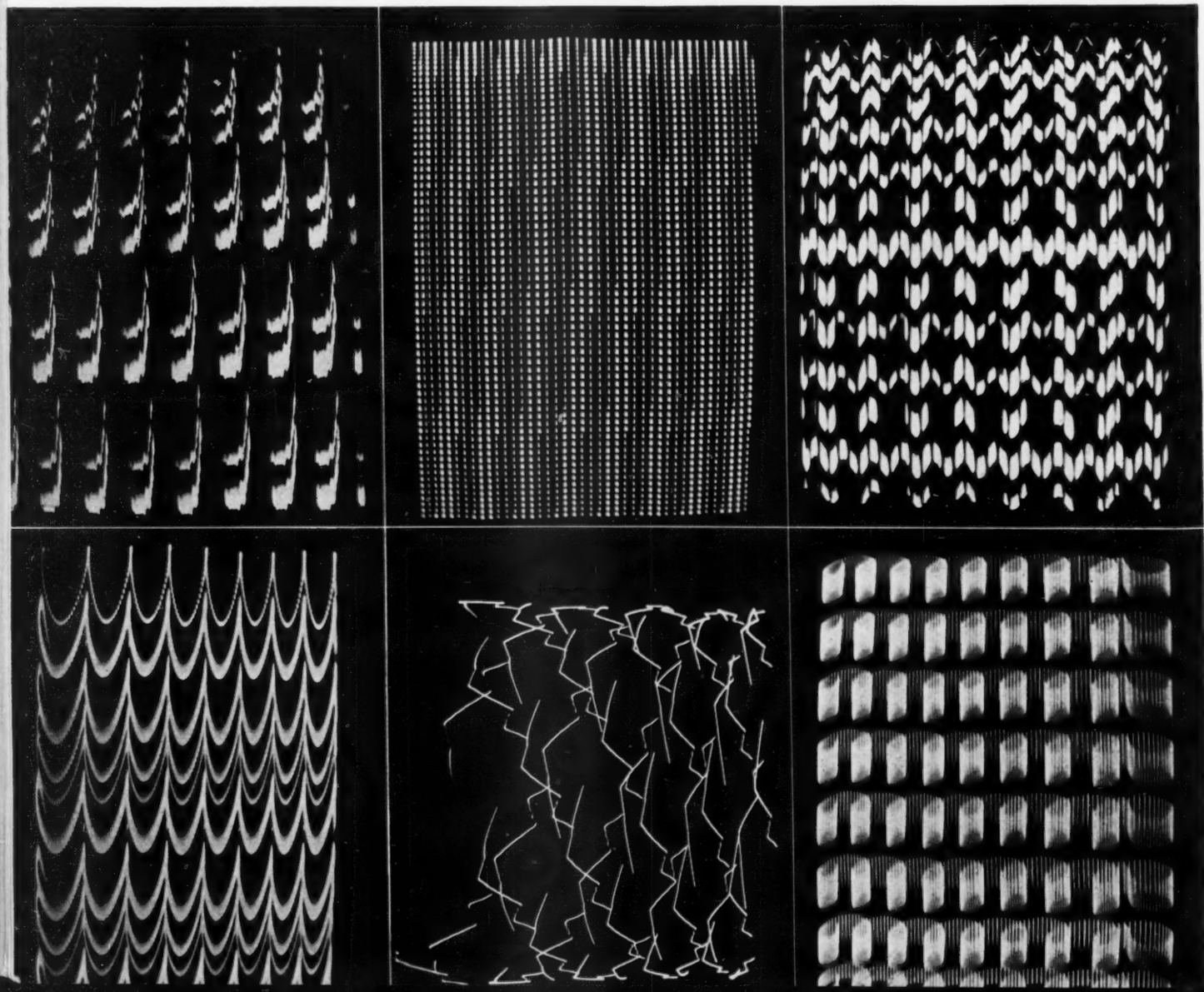
Since the application of plate voltage to T_3 before the cathode has reached its temperature impairs the life of the tube, a switch or time-delay relay should be incorporated in the plate circuit.

The power supply of this device is dangerous since sufficient energy is stored when all the condensers are charged to be fatal if one should make good contact across the main leads. Precautions must therefore be taken to encase the high voltage wiring in insulation sturdy enough, both physically and electrically, to protect the operator.



ELECTRON GUNFIRE

PATTERNS formed on a cathode-ray tube screen by C. E. Burnett of RCA Radiotron, using equipment originally designed to test the resolution of television picture tubes. The images were produced by random manipulation of the 40 controls associated with 12 multivibrators, 10 mixing amplifiers, modulation and sync circuits



A VISUAL ALIGNMENT GENERATOR

An all-electronic frequency-modulated signal generator for r-f and i-f alignment using an oscilloscope. The central frequency is continuously variable from zero to 60 Mc, and the total frequency sweep from zero to 1.1 Mc, all without the use of moving parts

By H. F. MAYER

General Electric Company, Schenectady

HAVING once aligned a tuned radio-frequency transformer by means of a cathode ray oscillograph and frequency modulated oscillator, one is apt to wonder how it was ever done without such equipment. While the aligning of critically-coupled transformers in production simply by adjusting for maximum output on a signal of fixed frequency is easy, and accurate enough for most purposes, the aligning of over-coupled transformers, without something to indicate the shape of the selectivity curve, is next to impossible. In developmental work, it is even more important to see the selectivity curve, for a double tuned transformer may in some cases have six variables to be adjusted: primary and secondary tuning, primary and secondary damping, and inductive and capacitive coupling. In general, if the shape of the selectivity curve is one of the things of interest, then the alignment equipment should be capable of continuously showing the shape of the curve.

For broadcast receiver production the system using a motor driven variable condenser connected across the tank circuit of an oscillator has proved entirely satisfactory. Since all superheterodyne receivers in production ordinarily use intermediate-frequency systems of the same nominal frequency and approximately the same band width, the same frequency-modulated signal suffices for all alignment stations. The oscillator may be made quite stable and a smoothly running condenser may be used to sweep the frequency consistently and uniformly over the necessary range of 20 or 25 kc.

In developmental work a more flexible system is needed. It is essential that the mean frequency of the signal be variable, the greater the range the better, and it is highly desirable that the amount of frequency modulation also be variable.

Some of these requirements are met by the simple combination of a motor-driven condenser with a multi-range variable-frequency oscillator. However, such a system, unless it is rather elaborate, may be quite limited in its applications. For example, the following difficulties may be encountered:

1. The frequency modulation may be accompanied by amplitude modulation, at some frequency settings.

2. The amount of frequency modulation cannot be varied, except in one or two steps at most.

3. The amount of frequency modulation depends upon the frequency setting, being greater, the greater the frequency. Thus, there may be insufficient modulation obtainable at the lower frequencies.

4. The wiping contact between the condenser rotor and ground may become dirty, causing unstable operation and disrupting the picture.

5. The rotating system, if not well balanced, may cause troublesome vibration.

The job of building some early models of frequency modulation receivers, in which intermediate frequencies of 6 Mc and 800 kc, with band widths of 150 kc, were used, precipitated the design of a completely electronic visual alignment signal generator, in which all the above defects were overcome. The new equipment has the following features:

1. There are no moving parts in

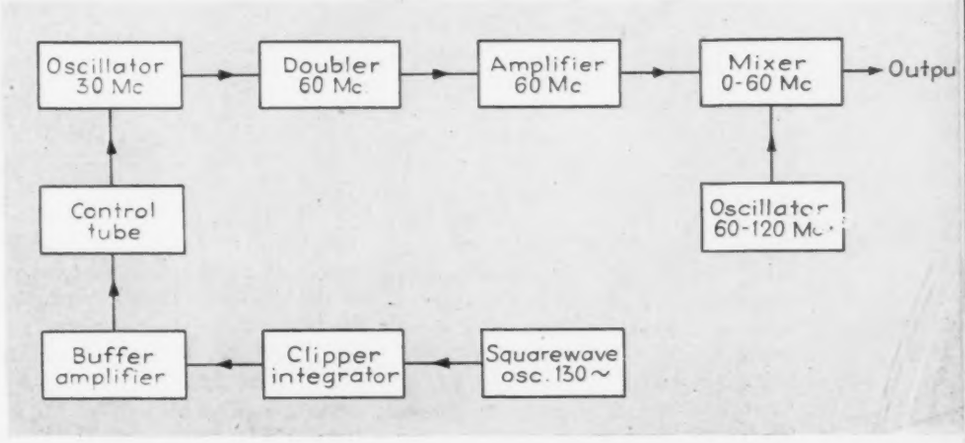


Fig. 1—Block diagram of the alignment generator, showing conventional carrier generator and electronic modulator

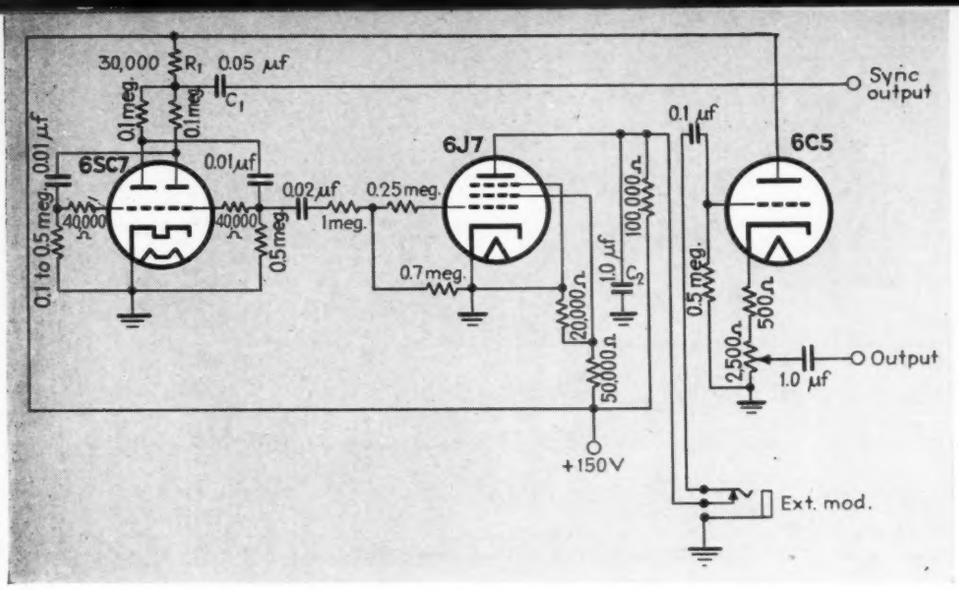


Fig. 2—Connection diagram of the "pyramid-wave" generator which controls the frequency-shifting tube. It consists of a multivibrator, clipper-integrator and buffer amplifier

the frequency modulator.

2. The mean frequency is variable from zero to 60 Mc, in a single range, without affecting the amount of frequency modulation.

3. The frequency modulation is variable from zero to 1.1 Mc.

4. By plugging in audio frequency, the oscillator may be frequency modulated with sine wave signal or program for testing frequency modulation receivers.

5. A pyramid wave of 130 cps voltage may be taken off from a jack for testing other equipment.

The block diagram (Fig. 1) shows the principle of the new device. A relaxation oscillator generates a square wave, which is clipped and integrated in the next stage to form a pyramid wave. This wave is applied through a buffer-amplifier to an electronic reactance tube circuit similar to those used to control the oscillator frequency in automatic-frequency-control circuits. This control tube is capable of causing a pyramidal undistorted frequency modulation of 550 kc peak to peak on the 30 Mc oscillator frequency. The oscillator output passes through a frequency doubler, the output of which is 60 Mc modulated 1.1 Mc total. This signal is then mixed with a signal whose frequency is manually variable from 60 to 120 Mc, resulting in an output frequency variable from 0 to 60 Mc without affecting the modulation.

The circuit of the pyramid wave generator is shown in Fig. 2. This generator could have been made without the 6SC7 relaxation oscillator by using the 60 cps supply to drive the clipper. However, it was deemed much preferable to have a pyramid wave not synchronous with the 60 cps supply. The reason for this is that occasionally some defect in the equipment being tested will cause some 60 or 120 cps voltage to appear in the output circuit, along with the voltage due to the frequency modulated signal. If the frequency modulation is synchronous with the spurious voltage, a stationary pattern is formed, and the resulting distorted shape may be misconstrued as due to misalignment, whereas it is really caused by trouble in some other part of the circuit. If the pyramid wave is not synchronous with the supply voltage, the presence of any such unwanted voltage is immediately evident from the motion of the pattern.

The output wave of the relaxation oscillator is actually far from square, as the oscillogram in Fig. 3A shows, but sufficient voltage is applied to the clipper tube to cause a square wave of plate current to flow in the plate circuit. This square wave of current, flowing through the parallel combination of a resistance and a capacitance which has small impedance at the fundamental frequency, results in a pyramid wave of voltage, as shown in Fig. 3B. A type 6C5 tube, with its load in the cathode circuit in order to obtain low impedance and low distortion, supplies the pyramid wave to the control tube. When audio voltage is plugged into the external modulation jack, it goes to the grid of the 6C5, automatically disconnecting the pyramid wave input.

Synchronizing voltage to lock the cathode ray oscillograph sweep in with the frequency sweep, in the proper phase, is obtained from resistor R_1 through a coupling condenser C_1. In the double trace system of alignment, which is most generally used, the cathode ray sweep frequency is twice the pyramid wave frequency. This gives a pattern consisting of two superimposed selectivity curves, one of which goes from low to high frequency and the other from high to low, as the spot moves from left to right. This necessitates a synchronizing pulse every half cycle. Since the resistor R_1 is common to the plate circuits of both triodes in the relaxation oscillator, the voltage across it will have the necessary double frequency. Fortunately the pulse of current in R_1, as one triode fires and the other cuts off, is quite adequate to synchronize the oscillograph. Since this pulse occurs exactly at the end of a half cycle, the phase is also correct. Fig. 3C shows the pyramid wave with the oscillograph externally synchronized by the double-frequency pulse.

The circuits of the oscillator and frequency modulator are shown in Fig. 4. No capacitance other than that contributed by the tubes and wiring is used across the tank circuit inductance L_2. This high L/C ratio is necessary in order to obtain the large frequency variation, since the number of micromicrofarads

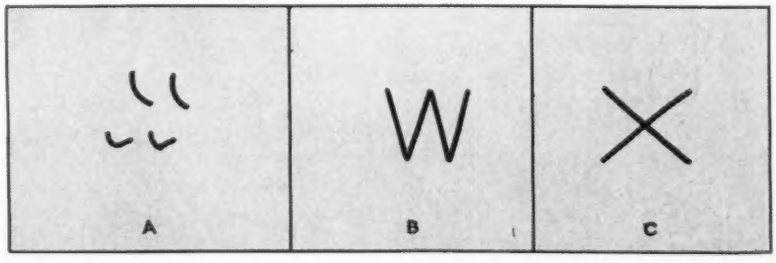


Fig. 3—Outputs of the circuits in Fig. 2: A, multivibrator; B, clipper; C, pyramid wave scanned at double frequency

which the control tube can simulate is limited. The components C_1, R_1 and L_1 serve to shift the phase of the tank circuit voltage so that the voltage at the grid of the control tube is 90 degrees ahead of the tank voltage. This causes the plate current of the control tube also to be 90 degrees ahead of the tank voltage, and the tube therefore looks like a condenser and changes the frequency accordingly. The pyramid wave voltage being also applied to the grid of the control tube, there is a variation of mutual conductance in accordance with the pyramid wave so that the effective capacitance varies in a like manner.

After frequency doubling and amplifying, the frequency modulated signal is mixed with the manually variable signal, in a 6L7 mixer, to provide the output signal.

In the photograph (Fig. 5) of the first sample of the equipment may be seen, from left to right, the modulation control, the external modulation jack, the tuning control, the output attenuator and the output and synchronizing binding posts. The pyramid wave output jack was not included on this early model.

The tuning dial is directly calibrated in mean output frequency, but since it is impractical to make this highly accurate, it is necessary when aligning circuits to a particular desired frequency to use an auxiliary, accurately calibrated oscillator or signal generator. If its output be connected in parallel with the output of the visual alignment equipment, the pattern will contain a zone in which the two signals are of nearly enough the same frequency to produce a visible beat. At the center of this zone will appear a point of zero beat, at which point the modulated frequency is equal to the fixed frequency. If the fixed frequency is set to the desired value, and the tuning of the visual alignment equipment varied until the zero beat points on the two traces coincide, then the circuit will be aligned at the desired frequency when the traces coincide.

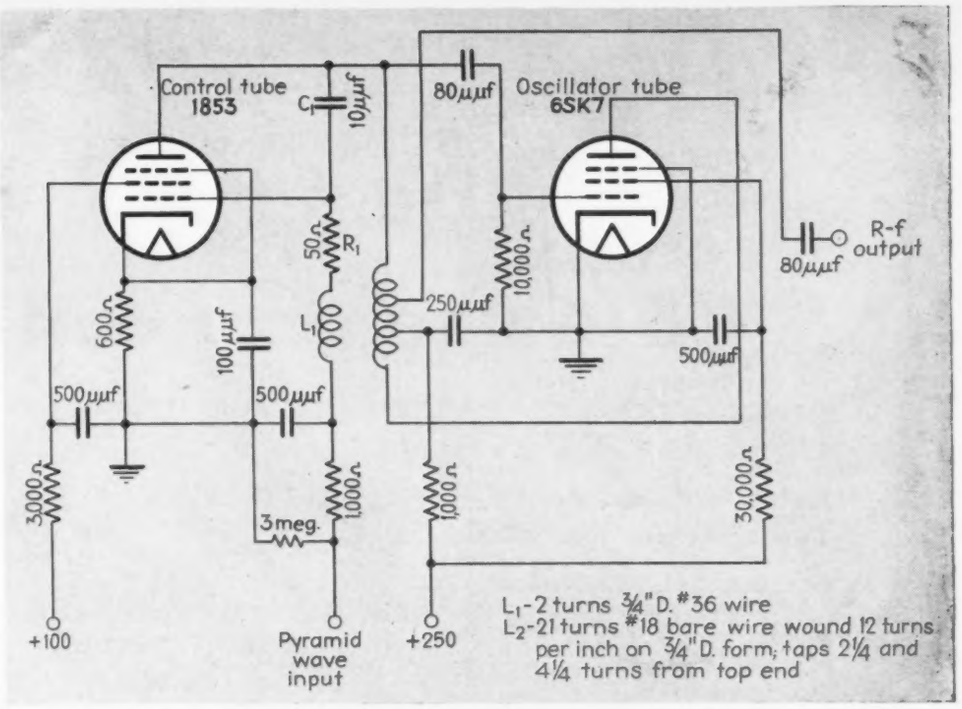


Fig. 4—Oscillator and frequency modulator. The pyramid wave acts on the control tube to vary the frequency in the oscillator

Fig. 5—External appearance of the generator. External modulation (see jack) may be used to test frequency-modulated receivers

Figure 6 shows some oscillograms taken using this equipment in aligning a frequency modulation receiver. At A is the i-f characteristic up to the limiter grid. Curve B is the characteristic through the detector. Both of these were taken with a frequency sweep of 300 kc. Curve C is the same but with a 150 kc frequency sweep.

This equipment has become an indispensable tool where it has been used. While, as pointed out above, it finds its greatest use in development work, it has on several occasions saved a great deal of time in aligning special production receivers where the quantity was not large enough to warrant the installation of a fixed frequency-modulated generator.

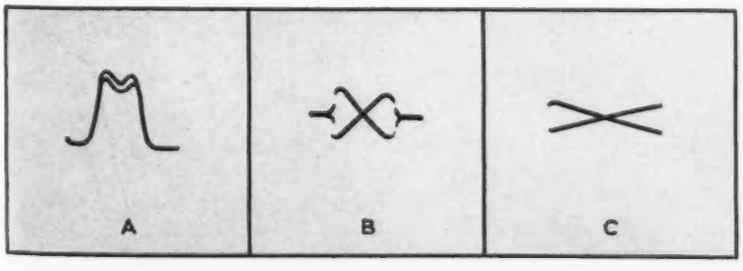
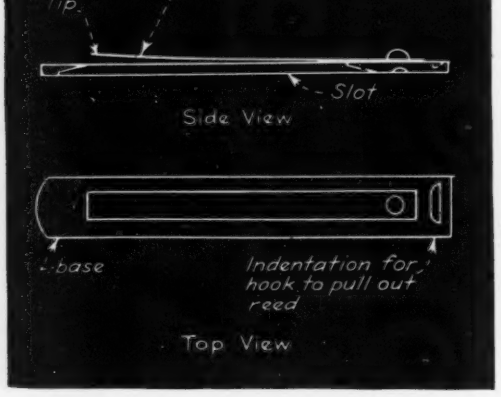
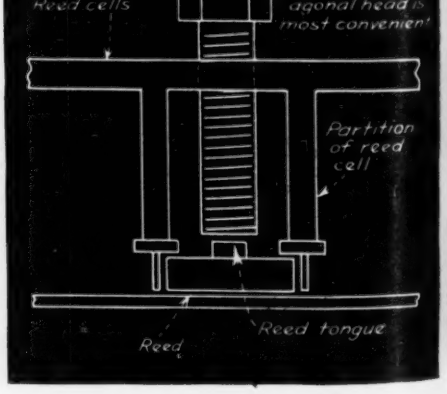


Fig. 6—Oscilloscope patterns produced in aligning f-m receiver: A, i-f response; B, overall detector characteristic; C, expanded overall characteristic



permits adjustment with an open ended wrench or pliers. The brass diminishes corroding and the flat end advantage is illustrated in Fig. 4. A concave or convex shape reduces the effective capacity between screw and tongue.

It is important to line up the screw and tongue accurately. This is accomplished by a special tool shown in Fig. 5. The left side of tool (as shown in the side elevation) is the same size as a reed base. The right side has three holes for marking the



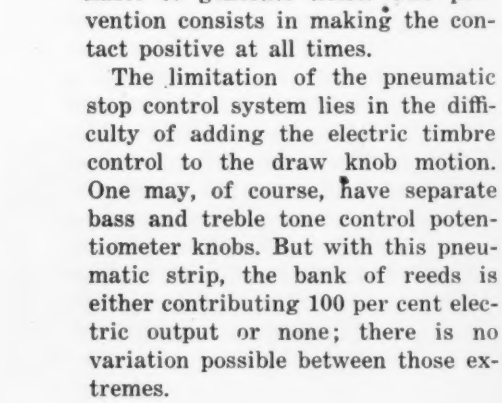


Fig. 6—Preamplifier input circuit. Care must be taken to protect the grid circuit from extraneous fields

Fig. 7—Method of varying the electric output from each bank of reeds. The polarizing voltage applied to the reed bases is varied by R_5

any intermittent metallic contact in the electrostatic pick-up field or grounding and shielding circuits is liable to generate noise. The prevention consists in making the contact positive at all times.

The limitation of the pneumatic stop control system lies in the difficulty of adding the electric timbre control to the draw knob motion. One may, of course, have separate bass and treble tone control potentiometer knobs. But with this pneumatic strip, the bank of reeds is either contributing 100 per cent electric output or none; there is no variation possible between those extremes.

The Pick-up Amplifier

Approximately 100 db gain is needed in the amplifier, with an input resistance of two megohms. The frequency range depends at its lowest limit on the lowest frequency reed used. The upper limit is about 6000 to 8000 cps. Of course, it is useless to have available a lower frequency limit than that the loudspeaker is capable of reproducing. The coupling of harmonium reeds to the air is extremely inefficient for frequencies below 100 cps and it is here that the electronic equipment may be made to out-perform conventional reed organs greatly by giving deep, rich bass tones. Remembering that the standard pitch of middle C is 261 cps and that of the A above, 440 cps, one can easily compute the lowest frequency on the instrument. Doubtless it will be 87, 43, or about 30 cps, depending on the reed ranks found in the instrument. An amplifier of not less than 15 watts undistorted power output, such as that given by a pair of type 2A3 tubes in push pull, should be used for good bass reproduction.

The amplifier must be free of perceptible cross modulation lest difference-frequency components mar the clarity of tones when playing. With beam power tubes in push pull, for example, unless about fifteen per cent inverse feedback is employed, the chordal distortion in the treble renders the performance unsatisfactory.

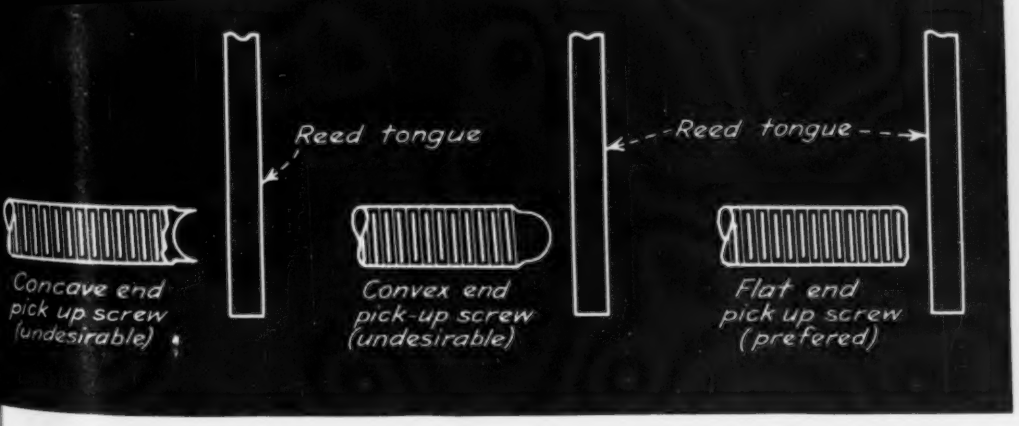
A typical pre-amplifier input circuit is shown in Fig. 6. It is much easier to construct a hum-free amplifier by having the pre-amplifier on one chassis and the power amplifier on another chassis. High impedance shielded cable leads may cause hum unless the shielding is insulated from ground except for the single connection to the one common grounding point.

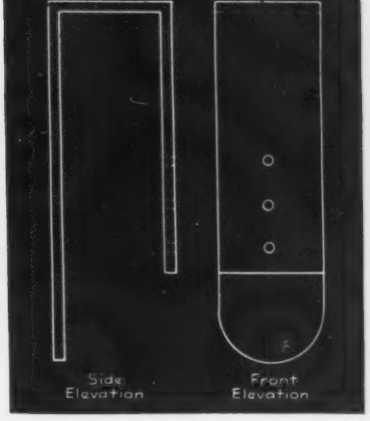
Organ Stops Controlled by Electrical Methods

It is usual with pipe organs to select the desired stop by pushing down a rocking tab or pulling out a knob. The pneumatic system has already been described. Two electrical methods will be explained below.

One may adjust the output signal from a given bank of reeds by varying the polarizing voltage on the bases, as shown in Fig. 7. To eliminate switching clicks a filter time delay arrangement must be included, as indicated by the resistors R_3, R_4, C_2 and C_3. Unfortunately, with full gain setting of a high power amplifier, the necessary time delay must run into seconds to eliminate all traces of clicks. If the switching could take place gradually, such as by slowly increasing pressure of a metallic conductor on soft aquadagged felt (the resistance would start at several megohms and gradually drop down to about 25,000 ohms) the

Fig. 8—Simplified circuit showing separate two stage pre-amplifiers (6F5 and 6C5 tubes) for each bank


Reed tongue
Reed tongue
Concave end pick up screw (undesirable)
Convex end pick-up screw (undesirable)
Flat end pick up screw (prefered)



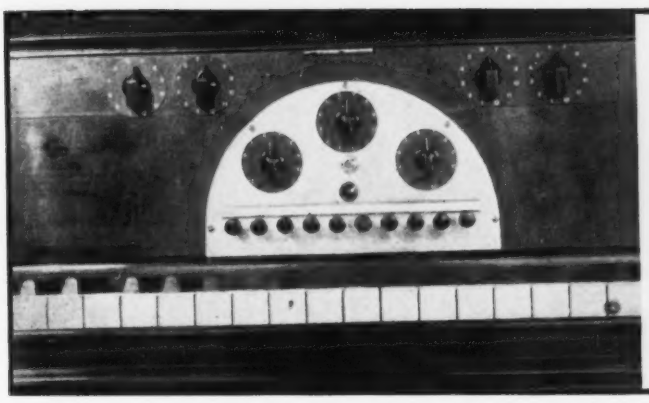


Fig. 9—Tone, set volume, and preset push-button timbre controls are mounted above the center of the keyboard

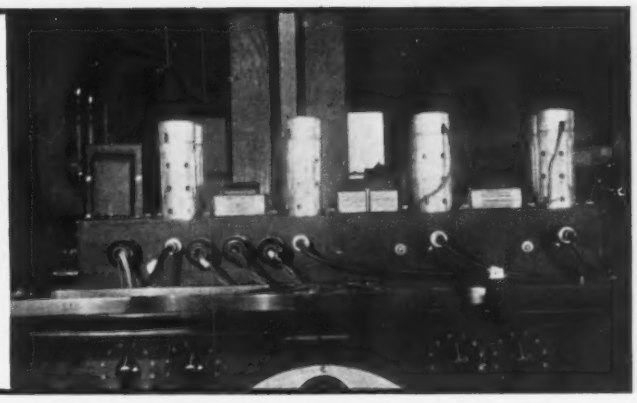


Fig. 10—Complete three-channel preamplifier chassis, arranged with widely separated grid input leads (at right)

time delay of the filter could be short to prevent click, but the design of such a multi-contact slowly closing switch does not appear practical for simple construction. Short circuiting the amplifier or loudspeaker during shifting of the polarizing voltage has no advantage since this method itself also brings in a click. A potentiometer may be useful for setting the polarizing voltage as a timbre control means, but this will not allow fast shifting of quality where there are pre-set combinations involving three reed banks and bass and treble tone controls. With the potentiometer, however, clicks will be negligible, since the voltage is varied continuously rather than in sudden jumps.

The third way to adjust the contribution from each reed bank is the most flexible, but also the most expensive and complex. It involves a separate pre-amplifier for each rank, switching and mixing each output together at low impedance such as 500 ohms, stepping up by a transformer to the following tube grid, and switching of series and shunt capacities in that grid circuit for timbre control. The simplified form of this circuit is shown in Fig. 8. In this method no clicks are produced, provided of course that no signal is being fed into the input during the switching.

The switch itself is of the interlocking type so that when one button is pushed in, another already in automatically releases. Assuming that the instrument contains three reed ranks and provision is to be made for bass, treble, and volume control, there will be six single pole single throw switches, or twelve blades in all, operated by one button. At least six and preferably twelve button sections are desirable for setting up as many different combinations. Several manufacturers of radio push button tuning switches can furnish the desired unit inexpensively.

Volume Control Swell Pedal

The volume control is essential to the organ since the pressure or impact of the fingers on the keys has no part in regulating the loudness of the tone. If the swell pedal is of the balanced type, the foot can adjust the gain setting and then leave the pedal for operation of the pedal keys. One will save time and money in the long run by obtaining at the beginning a long-lived potentiometer guaranteed for a million or more rotations, since ordinary radio volume controls invariably become noisy after a little usage. There are several now on the market that may be obtained for less than two dollars.

A pre-set volume control in front of this potentiometer in the preamplifier common channel is necessary to avoid turning the gain beyond the point at which overload and distortion appears in the loudspeaker.

Choice of the Loudspeaker

A twelve-inch loudspeaker is the smallest that can be recommended for adequate volume and the 15-inch electro-dynamic is preferred. The low frequency pedal tones can only be reproduced with a large baffle plane, infinite baffle arrangement (sound absorbing back) or bass reflex. Resonant sound chambers for accentuating the bass have the undesired weakness of dulling the stridency of tones and lengthening the damping period, but some economical compromise must be effected between deepness of bass and brilliancy of treble. Trained ears will quickly detect a synthetic bass which lacks real strength in the fundamental, or perhaps one should say the sense of feeling detects the deficiency, since the bass tones are felt as much as they are heard.

No organ would be complete without a tremulant, which introduces a low-frequency variation in volume. The most obvious way to arrange this is to vary the amplifier gain at a periodic rate between six and twelve times a second, and thus the loudspeaker volume rises and falls. A superior scheme would raise and lower the frequency of all the notes along with a change in their volume. This may be brought about in the familiar Doppler effect by arranging a single paddle to move to and fro in front of a loudspeaker. Alternate pulses push out the air and pull it in so that the frequency fluctuates as well as the volume. The pivot axis is towards the base of the celotex board. With many reed organs there is already a pneumatic provision for tremulant by rapidly opening and shutting the air equalizer chamber.

Installation of Amplifier and Loudspeaker

The amplifier and loudspeaker are preferably placed within the organ console if space permits this. In any case, the pre-amplifier section should be inside the organ to keep the lead from pick-up screws to input short. It is best to have that lead formed of high-voltage auto ignition cable tc insure against leakage noises. To eliminate loading the pick-up system with the dead capacity of shielding for this lead, no shielding is used unless it is necessary to prevent a-c hum. At this highly sensitive input,

(*Continued on page* 97)

A Feedback Welding Timer

By J. KURTZ

Callite Division, Eisler Electric Corp.

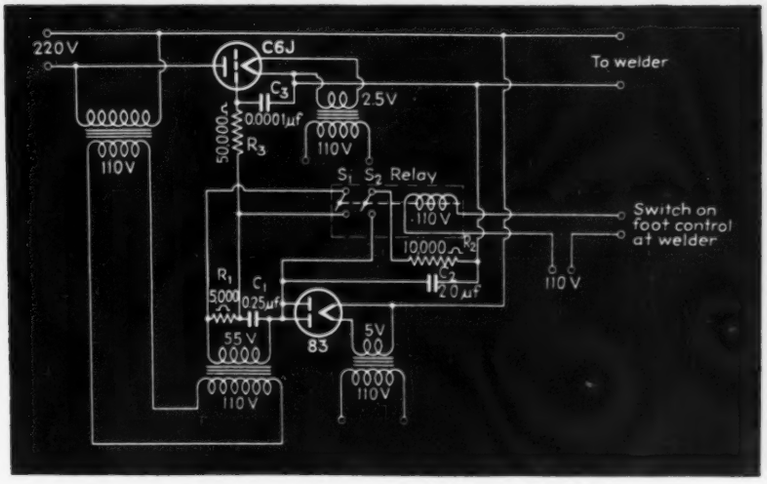


Fig. 1—Circuit of the timer. The output of the control tube is fed back to the rectifier tube and grid control circuit

THE half-cycle electronic timer for small parts welding, illustrated and described here, has been engineered and constructed for welding operations in the radio tube industry. In such work, where extremely short but uniform welding time is important, these units have proven their effectiveness over a considerable period of time, providing not only uniform welds but freedom from excessive oxidation and sticking of the electrodes.

It is not generally appreciated that in welding thin materials the weld comes up to temperature much faster than in the usual weld due to the small amount of metal being heated. Continued application of current thereafter serves only to heat up the electrodes and increase the tendency for the work to stick to the electrode.

Not the least advantage offered by this unit is its simplicity, making it inexpensive, easy to install and trouble-free in service. Fundamentally, it is a device which limits the current application for each weld to the time duration of a single and complete half-cycle of the 60-cycle supply line, regardless of the instant of closing the contactor. This is accomplished through the use of a grid-control rectifier tube in the circuit shown in Fig. 1. This tube, connected in series with the primary supply to the welder, is capable of handling primary currents up to 77 amperes and is intended for use in 110, 220 or 440 volt supplies. The tube is a product of Electrons, Inc., Newark, N. J., and known as their type C6J.

In the idling position of the timer, alternating current is applied to the grid exactly 180 degrees out of phase with the anode so that at no time during the cycle are the firing conditions satisfied. The grid bias is obtained through a transformer providing secondary voltage of 55 and energized from the same line that supplies the anode, but connected for out-of-phase operation. Actually the schematic diagram of Fig. 1 shows two transformers here, the reason being that these are standard and more readily available than a single 220-55 volt unit.

In Fig. 1 the idling position is with relay contacts S_1 and S_2 closed. When the foot-switch at the welder is depressed it energizes this relay, opening both circuits. Opening of S_1 inserts R_1 in the 55-volt secondary circuit and this, in conjunction with C_1, causes a phase shift of a few degrees in the voltage applied to the grid, with the result that at some point in the cycle the tube will fire, and current will be supplied to the welder. The grid is positive for the first few degrees of the positive plate cycle. As this is the only part of the cycle during which firing conditions are satisfied, no current flows after closing S_1 until the beginning of the next succeeding positive half cycle, at which time a complete half cycle of line voltage loses control as long as the anode is positive. The current drawn during this period depends on the welder and is practically unaffected by the tube. While the tube is conducting, the capacitor C_2 is charged through the 83 rectifier with a resulting high negative bias on the C6J grid which prevents firing on succeeding cycles. The network R_2C_2 is provided to eliminate supply voltage disturbances from the grid circuit. With release of the foot-switch at the welder the relay contacts close. S_2 allows C_2 to discharge through R_2 while S_1 shorts out R_1 allowing the 180 degree out-of-phase idling operation of the C6J tube to be resumed.

The photographs show a typical example of the unit. This unit is assembled on a standard 10 x 7-inch radio chassis and inclosed in a standard switch box the knockouts of which provide ventilation.

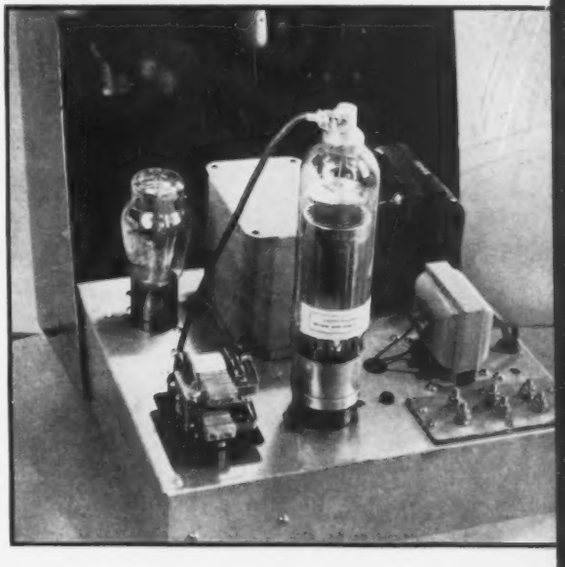
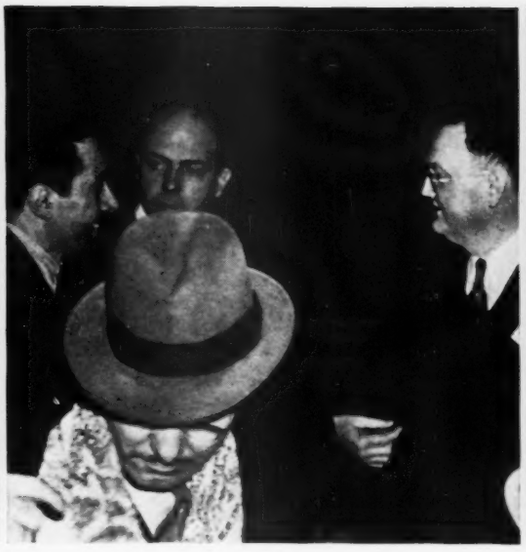


Fig. 2—The welding timer with cover removed. The large tube is the C6J control thyratron

War and propaganda have made America's participation in international broadcasting, discussed by Gerald Gross of the F.C.C., a vital concern



Andy Ring (right) of the F.C.C. compares f-m and a-m with Messrs. Wilmotte and Everitt. Mr. Wilkins, having heard plenty of the same, puts on his hat and coat

Raymond Guy of N.B.C. pauses on the platform after his dissertation on the Empire State Television Station, with Professor Everitt and Paul Loyet

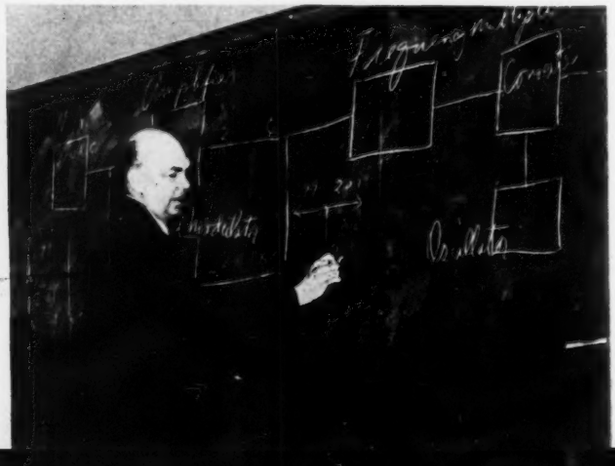
BROADCASTERS AT COLUMBUS

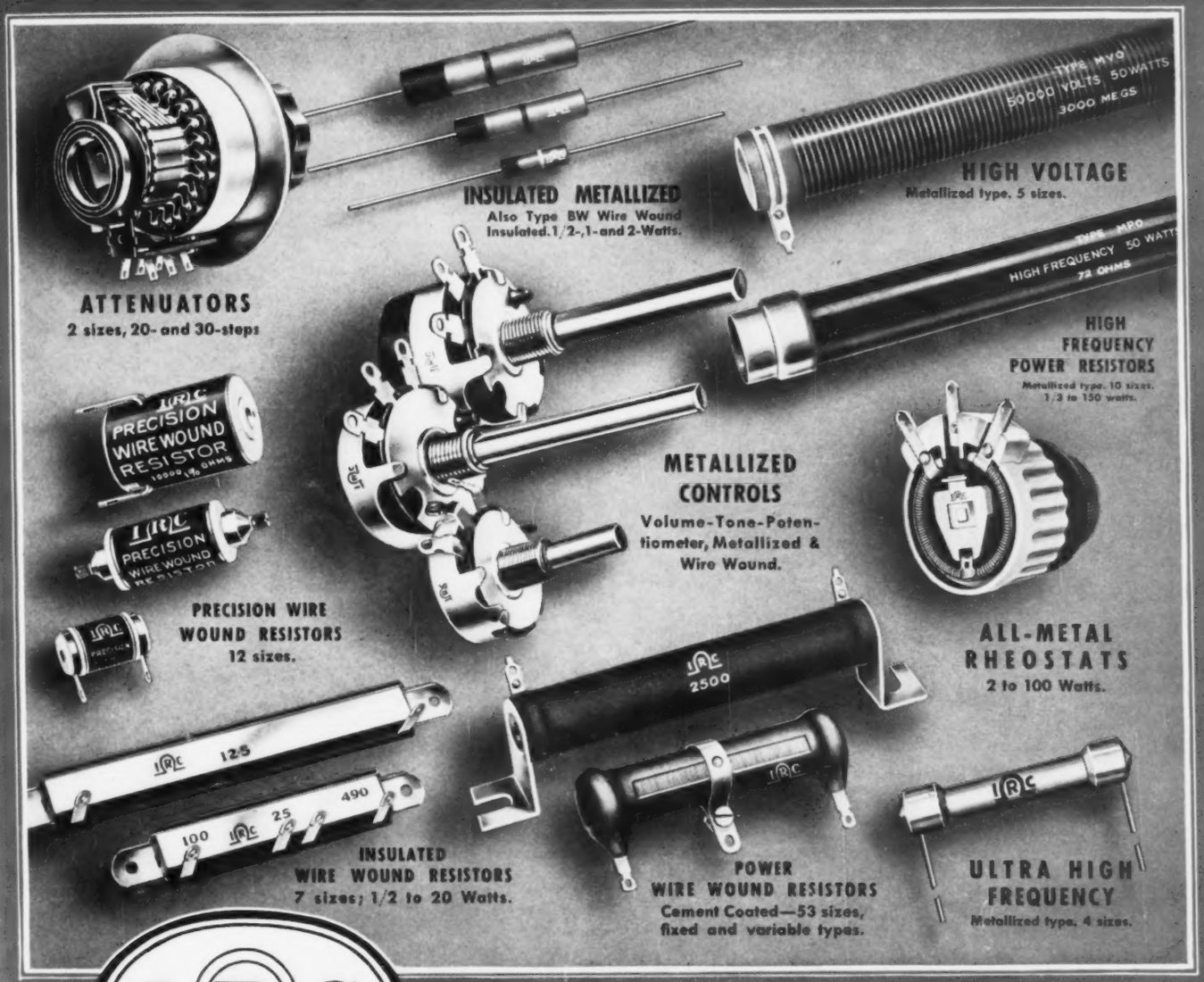
Students and teachers at the 1940 Broadcast Engineering Conference, latest annual symposium held at Ohio State University under the direction of Professor Everitt

H. O. Peterson of R.C.A. Communications discussed ultra-high frequency propagation, a topic of growing interest to the broadcasting fraternity

W. H. Capen of International Telephone and Telegraph rises to ask a question, which apparently interests the rest of the audience

Direct from the foremost authority and leading exponent, the audience hears Major E. H. Armstrong describe his system of frequency modulation via the well-known vector diagram





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New Books

Handbook of Physics and Chemistry

BY CHARLES D. HODGMAN, *23rd edition, 2221 pages, Chemical Rubber Publishing Co. Price, $6.00.*

EVERY EDITION OF THIS valuable reference work contains more data than the last, and in this edition not only the number of pages, but the page size has also been increased. The main sections include: mathematical tables, properties of physical constants, general chemical tables, specific gravity and properties of matter, heat, hygrometric and barometric tables, sound, electricity and magnetism, light, quantities and units, and miscellaneous. The numerous tables and constants have been brought up-to-date by two score collaborators and contributors, each of whom is a recognized authority.

The book will be of interest to all technical workers in the natural sciences. The mathematical tables and formulas, the 14 pages of radio formulas, 24 pages of tabulated tube characteristics, 2 pages of tube socket connection, conversion factors for decibels, will be among the many items which electronics engineers will find useful. The tube list is divided into receiving tubes, telephone and industrial tubes, transmitting tubes, gaseous rectifiers, high vacuum rectifiers, and grid controlled rectifiers.—B. D.

A.S.T.M. Standards on Electrical Insulating Materials

Prepared by Committee D-9, T. SMITH TAYLOR, CHAIRMAN, *American Society for Testing Materials, 260 S. Broad St., Philadelphia, October 1939 (issued annually), 309 pages, $2.00.*

THIS BOOK CONTAINS specifications and methods of testing a wide variety of electrical insulating materials. The following materials are included:—Insulating varnishes, lacquers and related products, covered by seven specifications and tests; molded materials (five standards); plates, tubes and rods (five standards including a method for testing phenolic molded laminated products) and solid electrical insulation; oils; glass including pin-type lime glass insulators, glass spool insulators and electrical porcelain; rubber products including rubber tape, gloves and matting; asbestos yarns, tape and roving, and cotton tape and various filling and treating compounds, untreated paper and mica products. Also included in this book are six important standardized procedures for electrical tests, namely, arc resistance of solid electrical insulating materials, dielectric strength, power factor, thermal conductivities of solid materials and insulation resistance. The book is certain to be of value to both producers and consumers of insulating materials in that it provides a basis for mutual understanding between the two parties. —C. W.

Radio Trouble Shooter's Handbook

BY ALFRED A. GHIRARDI. *Radio & Technical Publishing Co., New York, First Edition, 1939. Price, $3.00, 510 pages, 134 illustrations.*

MORE THAN HALF of this book is devoted to case histories of 3,313 models of 177 different makes of home and auto receivers. It is well known that many receivers become afflicted with particular troubles which are peculiar to that receiver. This case history section points out these troubles, how to recognize them and how to correct them. There are 51 other sections included in the book covering a wide variety of subjects which are useful to the serviceman. Several sections are devoted to problems relating to auto radio servicing. Recorders, sound systems and inter-communicators are also covered. The book explains much of the mathematics and numerical standards with which the serviceman must be familiar. A directory of manufacturers of receivers and components is given. This seems to be one of the most complete radio service books published thus far.—C. W.

The Elements of Radio-Communication

BY O. F. BROWN, *M.A., B.Sc. (Oxon), B.Sc. (Lond.)* and E. L. GARDINER, *B.Sc. (Lond.). Oxford University Press, London, Second Edition, 1939. Price, $6.00, 551 pages, 174 illustrations.*

TO THE GENERAL READER who desires a background of the principles and the history of radio, this book will undoubtedly prove to be of value. The clear and simple wording of the first edition is retained wherever it remains suitable. For this reason there are several subjects which are approached from the standpoint of early methods and subsequently from a more modern angle. It is stated by the author in the preface that radio communication can only be fully understood if the historical stages which have led up to its present state are appreciated. It will be found that the earlier stages tend to repeat themselves in modernized form. Thus the original ultra-short waves demonstrated by Hertz, after many years in which they were considered useless, are now of great importance and the original Fleming two-electrode tube has become the widely used diode detector.

The explanations of radio phenomena and the underlying reasoning are made in a clear manner which will appeal to the general reader. In some cases it may be thought that the subject is not treated with sufficient depth, but it must be remembered that this is intended as an elementary text and such explanations should be considered as introductions to more advanced studies.

The intention of the book is to be comprehensive rather than to give explanations of great depth. Therefore, several subjects such as cathode-ray tubes and electron multipliers are included which do not ordinarily appear in elementary texts on radio. There is also a chapter on antenna design along with reference to several recent developments including air navigation by radio, ultra-short-wave transmission and the quartz crystal filter. —C. W.

Production and Direction of Radio Programs

BY JOHN S. CARLILE (*Production Manager, Columbia Broadcasting System.*) *Prentice-Hall, Inc. 397 pages, 1939, $3.75.*

THIS BOOK FOR the non-technical departments of modern broadcasting stations covers the processes of producing and directing radio programs from the inception of the program idea to its final presentation on the air. Chapter headings give an idea of the contents, viz., The Program and Those Who Produce It, The Production of Musical Programs, Precision and Routine, Speech. Within these few chapters will be found a great deal that should be known to everyone who has anything to do with broadcasting, not excepting the engineers, the announcers, the gain control men—and the station owners. Anyone who has a yen to go on the air, with speech or musical program should be instructed properly in the art by a thorough perusal of this book, written by the production manager of one of the world's largest broadcasting systems.

This reviewer, more at home with what happens between the mike and the loud speaker, found himself vastly interested in the description of the technique of what happens within the studio and in front of the mike. It is recommended to engineers—and of course to the non-technical people. A much better idea of the importance of coordination and cooperation between technical and artistic people cannot but help both—K. H.

The ELEMENTARY PARTICLES

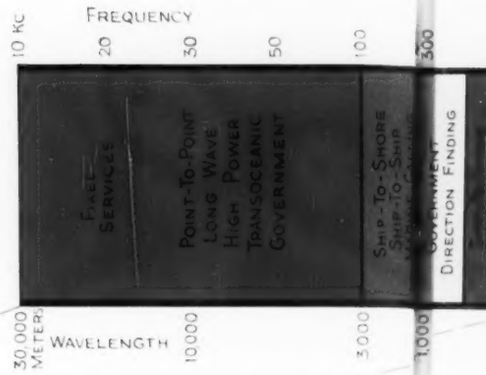
NAME	COMPOSITION	CHARGE	MASS
Neutrino*	Unknown	Zero	Variable
Electron	Elementary	−1	1
Positron	Elementary	+1	1
Proton	Elementary	+1	1830

Charge: $1 = 4.803 \pm 0.003 \times 10^{-10}$ e.s.u
Mass: $1 = 0.911 \times 10^{-27}$ grams

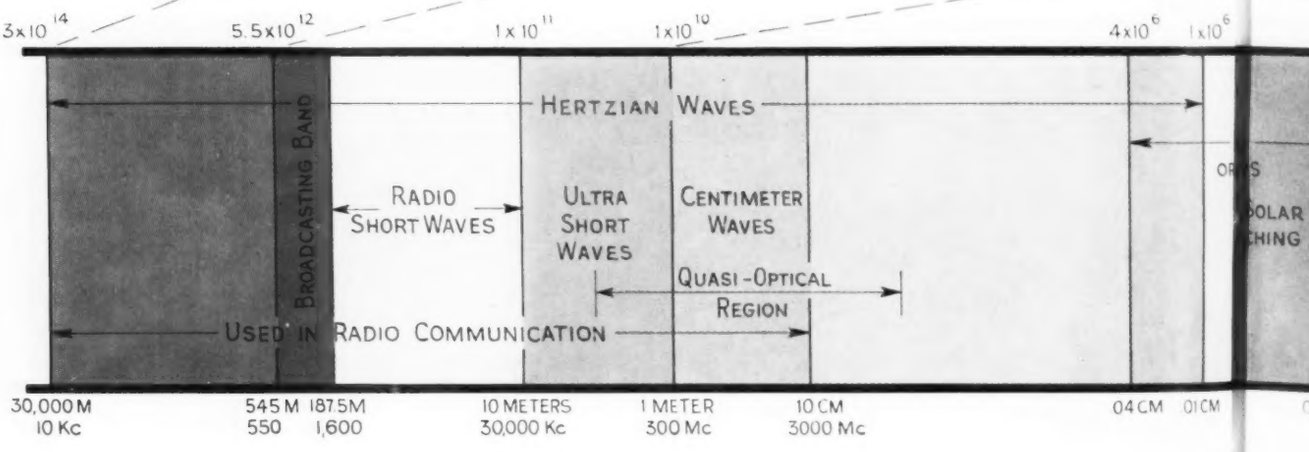
NAME	COMPOSITION	CHARGE	MASS
Neutron	1 Proton / 1 Electron	Zero	1830
Deuteron	1 Neutron / 1 Proton	+1	3660
Alpha Particle	2 Neutrons / 2 Protons	+2	7320

*Neutrino postulated on theoretical grounds. Existence not yet proved

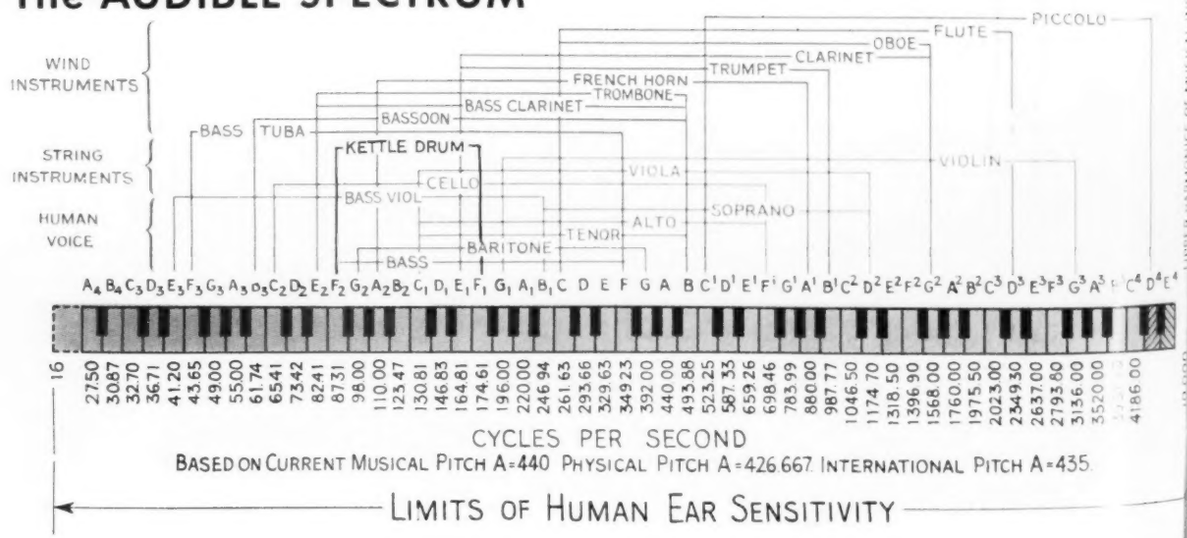
The RADIO SPECTR



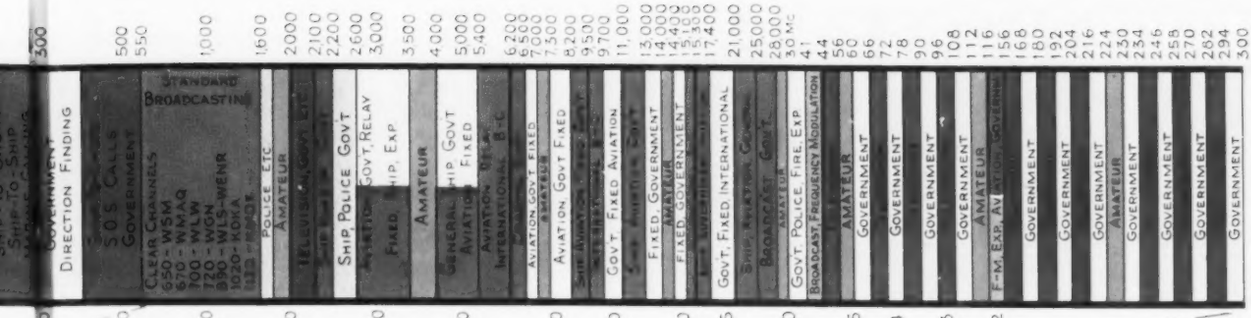
The ETHER SPECTRUM

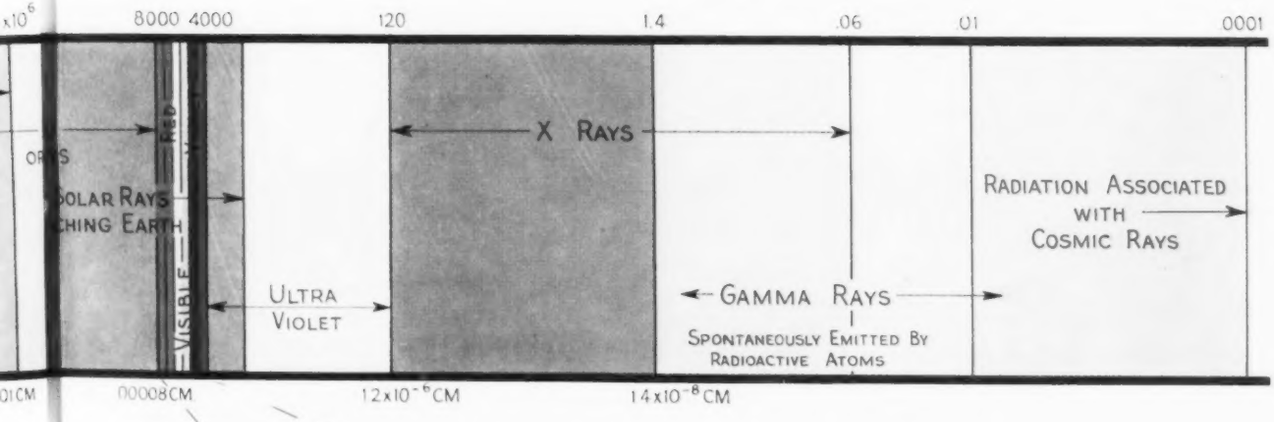


The AUDIBLE SPECTRUM

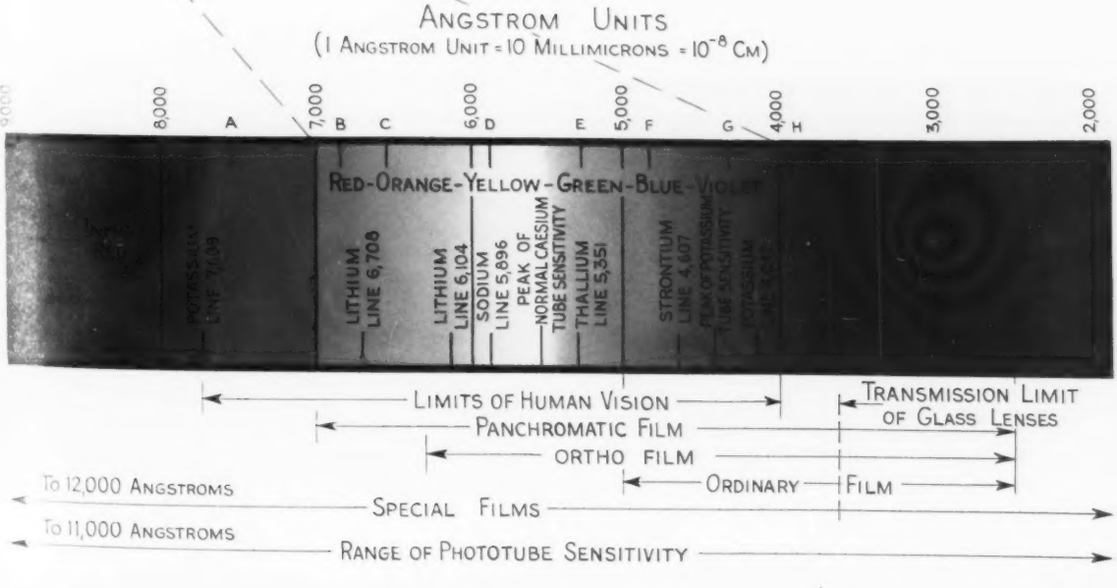

WIND INSTRUMENTS
STRING INSTRUMENTS
HUMAN VOICE
PICCOLO
FLUTE
OBOE
CLARINET
TRUMPET
FRENCH HORN
TROMBONE
BASS CLARINET
BASSOON
BASS
TUBA
KETTLE DRUM
VIOLIN
VIOLA
CELLO
BASS VIOL
SOPRANO
ALTO
TENOR
BARITONE
BASS
A4 B4 C3 D3 E3 F3 G3 A3 B3 C2 D2 E2 F2 G2 A2 B2 C1 D1 E1 F1 G1 A1 B1 C D E F G A B C1 D1 E1 F1 G1 A1 B1 C2 D2 E2 F2 G2 A2 B2 C3 D3 E3 F3 G3 A3 B3 C4 D4 E4
16
2750 3087 3270 3671 4120 4365 4900 5500 6174 6541 7342 8241 8731 9800 11000 12347 13081 14683 16481 17461 19600 22000 24694 26163 29366 32963 34923 39200 44000 49388 52325 58733 65926 69846 78399 88000 98777 104650 117470 131850 139690 156800 176000 197550 202300 234930 263700 279380 313600 352000 418600
CYCLES PER SECOND
BASED ON CURRENT MUSICAL PITCH A=440 PHYSICAL PITCH A=426.667 INTERNATIONAL PITCH A=435
LIMITS OF HUMAN EAR SENSITIVITY

ELECTRONI





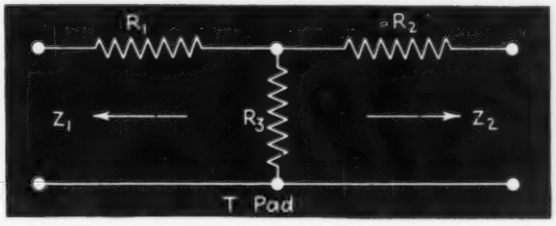
The PHOTOGRAPHIC SPECTRUM

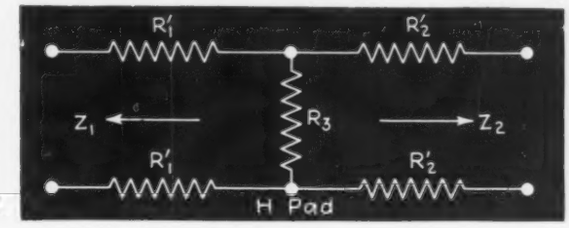


FORTY
COMMONLY USED PADS

By AARON SHELTON
Station WSM

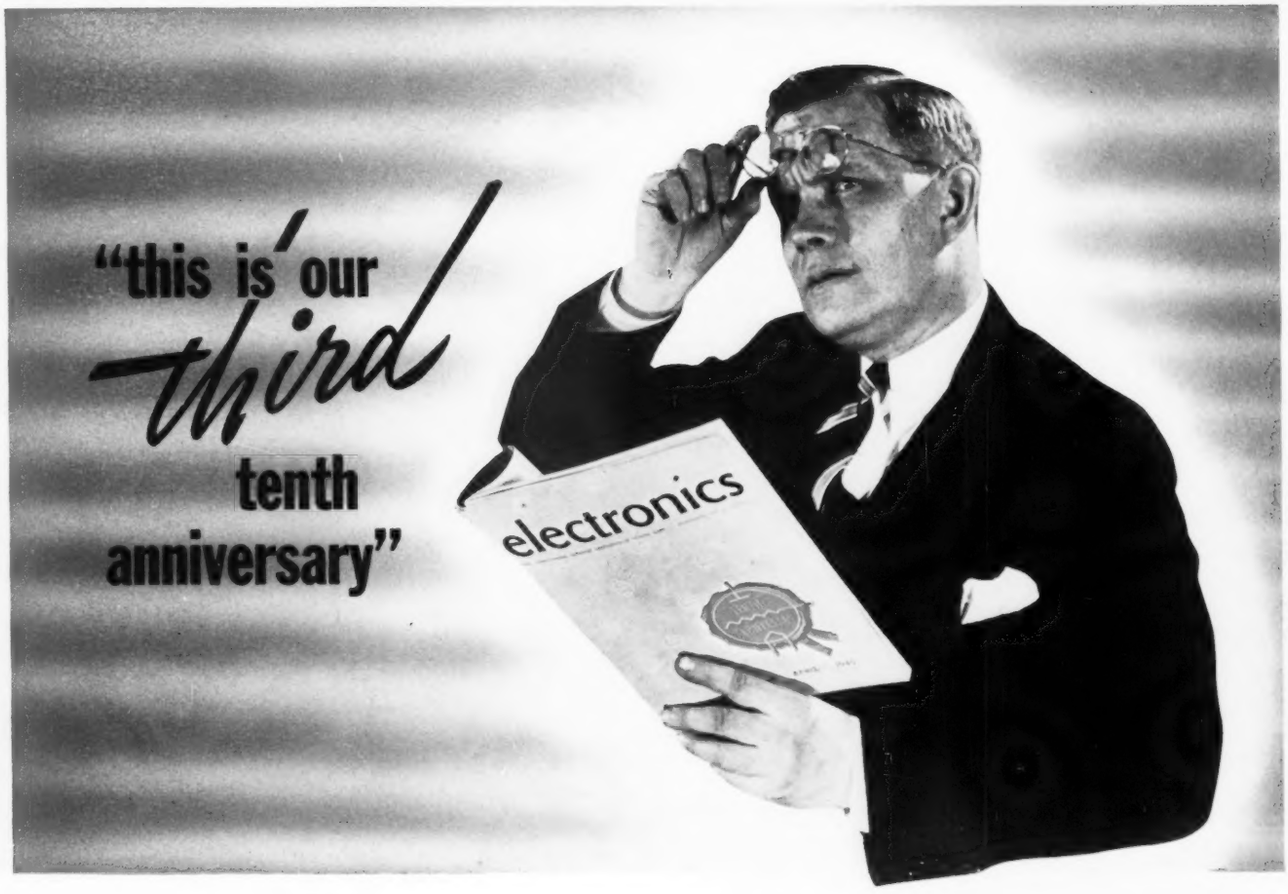
Table of values of the elements of resistive attenuators for various input and output impedances commonly encountered in communications circuits





$Z_1 \leftarrow\ \rightarrow Z_2$ Ohms	Loss	R_1 Ohms	R_2 Ohms	R_3 Ohms	$Z_1 \leftarrow\ \rightarrow Z_2$ Ohms	Loss	R_1 Ohms	R_2 Ohms	R_3 Ohms
50 to 50	5 db	14	14	83	500 to 500	5 db	138	138	834
"	10 db	26	26	35	"	10 db	258	258	352
"	15 db	35	35	18	"	15 db	350	350	183
"	20 db	41	41	10	"	20 db	410	410	100
50 to 200	Min Loss 11.5 db	0	175	57	500 to 2000	Min Loss 11.5 db	0	1755	575
"	15 db	16	175	37	"	15 db	168	1775	366
"	20 db	31	185	20	"	20 db	307	1837	203
50 to 500	Min Loss 15.8 db	0	475	53	500 to 5000	Min Loss 15.8 db	0	4750	528
"	20 db	20	480	31	"	20 db	190	4780	321
50 to 2000	Min Loss 22 db	0	1980	50	2000 to 2000	5 db	570	570	3330
200 to 200	5 db	35	55	334	"	10 db	1040	1040	1410
"	10 db	103	103	140	"	15 db	1400	1400	735
"	15 db	140	140	75	"	20 db	1634	1634	406
"	20 db	163	163	40	2000 to 5000	Min Loss 9 db	0	3910	2590
200 to 500	Min Loss 9 db	0	380	270	"	15 db	980	4170	1160
"	10 db	23	390	222	"	20 db	1400	4460	640
"	15 db	98	417	116	5000 to 5000	5 db	1370	1370	8330
"	20 db	140	436	64	"	10 db	2600	2600	3520
200 to 2000	Min Loss 15.8 db	0	1886	214	"	15 db	3500	3500	1830
"	20 db	76	1912	128	"	20 db	4085	4085	1015

To change T pads to balanced H pads, simply make resistances R_1' and R_2' equal to one-half the values as shown for R_1 and R_2 in the T pads



CORNELL-DUBILIER salutes *Electronics* on its first 10th Anniversary. We know that proud feeling.

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The new decade saw capacitors established. The years to come were to be — for Pioneer Cornell-Dubilier, at least — *Research* years . . . years devoted to experiment, development and perfection.

For Broadcasting had come into its own. Soon it was growing with the dazzling speed of Jack's storied beanstalk. With that growth came a sense of responsibility —of an obligation owed to the public. If Radio was to serve, it would have to be *reliable*. Radio *is* reliable today. Its reliability is, in fact, the marvel of our time.

Yet to *Electronics* and its readers, this is not nearly so *marvelous* as the manner in which it has been accomplished. For you know that Radio's reliability rests, every hour of every day, solely upon the *dependability* of the equipment used.

Cornell-Dubilier is proud of the role it has played during the past thirty years in the development of Radio Broadcasting. And if "the penalty of Leadership" be untiring research and industry, then C-D has more than paid the price. *For Cornell-Dubilier, the Pioneer, is, today, the world's largest exclusive capacitor manufacturer.*

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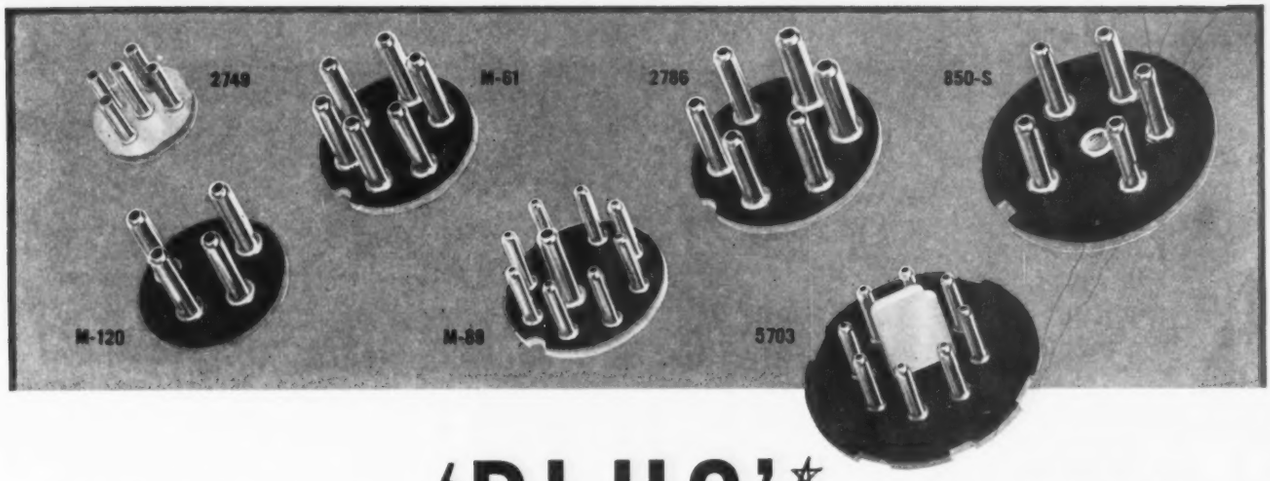
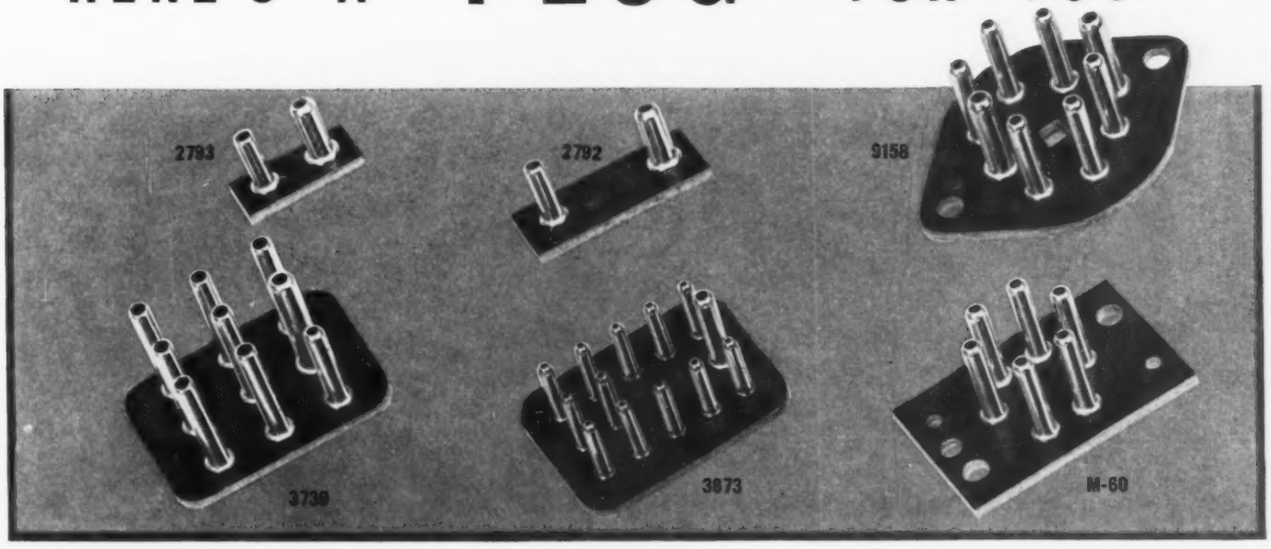
CORNELL-DUBILIER ELECTRIC CORPORATION

1006 HAMILTON BOULEVARD • SOUTH PLAINFIELD, N. J.



HERE'S A 'PLUG'☆ FOR YOU—



"Users of CINCH plugs and connectors are the makers of America's finest radio sets"

—and that is the record Long and certain service is the rule with Cinch parts. Just plug in and be sure with CINCH connectors.

All plugs, illustrated here in actual size, are polarized and vary from one to thirteen prongs

Metal shells with substantial internal insulations are made for most of the plugs. Also supplementary plugs with shells can be had . . . There is a chassis mounting socket to match every plug illustrated.

Pins $\frac{3}{32}$" in diameter are available in either $\frac{3}{8}$" or $\frac{7}{16}$" lengths. The $\frac{1}{8}$" and $\frac{5}{32}$" diameter pins in either $\frac{3}{8}$", $\frac{9}{16}$" or $\frac{11}{16}$" lengths. While the standard finish of pins is nickel, silver plating or "Cinch Solder Coating" may be had on request.

Cinch and Oak Radio Sockets are licensed under H. H. Eby socket Patents

CINCH MANUFACTURING CORPORATION
2335 W. Van Buren Street, Chicago, Illinois
SUBSIDIARY OF UNITED CARR FASTENER CORP., CAMBRIDGE, MASS.

TUBES AT WORK

Measuring altitude by acoustic reflection, a rotating-machine mechanical amplifier, a simple station-break chime, and 250-mile television relay, are among the technical achievements this month

Electro-sonic Altimeter For Aircraft

By JOHN H. JUPE

SAFETY IN THE AIR has been greatly increased by the recent introduction of a new altimeter in Great Britain. It is based on the well-known principle of measuring the time taken for a sound wave to be reflected back to the generating source. This principle has been used in marine sounding apparatus for many years and as far back as the last war was used on aircraft, in a crude form.

The new instrument is designed to operate entirely from a 24 volt storage battery, which drives a motor driven alternator. Sound is generated by allowing the motor to speed up to about 10,000 rpm and then short circuiting the alternator rotor across the voice coil of a moving coil loudspeaker. This speaker has a small metal diaphragm in place of the usual one and so favors the higher audio frequency vibrations. The duration of the outgoing pulse is 1/100 second and is repeated at one-second intervals.

Alternating current is also obtained from the generator to provide high voltage anode supply for the tubes used in the reception amplifier, for this purpose it is of course stepped up in voltage and then rectified.

On its return to the aircraft, the reflected sound impulse is received by a special unit consisting of a frequency selective moving coil microphone, preceeded by an acoustic filter chamber to remove unwanted engine noises. The microphone voltage is amplified by a two stage pentode amplifier and then passed on to operate a recorder or indicator.

Usually the recorder is of the starch-iodine paper type and the resulting graph gives the contour of the ground being flown over, directly. An indicator for direct reading is manufactured, based on the vibrating reed frequency meter used on power circuits. In this case an arm is arranged to revolve behind the reeds, driven by the 24-volt motor. As the arm, which carries a coil, passes the zero mark on the scale an impulse is sent out from the machine. Slightly later and depending on the echo time of the returning wave, the coil will be energised by the amplified return impulse and so cause the adjacent reed to vibrate.

Where a recorder is used the stylus will sweep to and fro across the damped starch-iodine paper and the outgoing impulse will occur when it is at zero mark. A brown dot will then appear at some other point on the chart, depending again on the echo time.

Intervals of one second are ample for both types of indicators and as is usual with the vibrating reed, group, the reeds on either side of the true point vibrate but with lesser amplitude. Height is read on a translucent illuminated dial.

So far as the transmitter and receiver are concerned the apparatus is mounted in the aft end of the fuselage, cone shaped horns about 20 inches in diameter being arranged flush with the external covering of the craft and mouth downwards.

For the time being, 750 feet is the maximum height at which the apparatus will work, this over grassland. Over water the figure is 450 feet but is still in the region of information which is valuable to the pilot and which will no doubt be extended by further research.

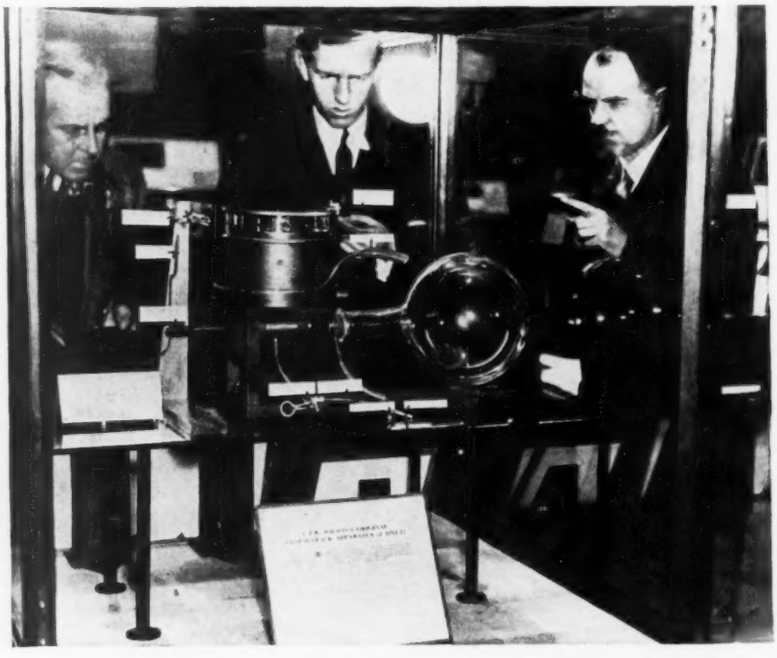
• • •

The Amplidyne—A New Mechanical Amplifier

AT THE WINTER CONVENTION of the American Institute of Electrical Engineers, Dr. E. F. W. Alexanderson, A. F. Fisher and M. A. Edwards, of the General Electric Company revealed a new type of generator known as the Amplidyne, which is capable of operating as an amplifier of control impulses in much the same manner as the vacuum tube amplifier, but at very much higher power levels. The Amplidyne generator responds almost instantaneously to changes in power input, that is, there is no perceptible time lag between adjustment of the input control and the response of the output. A total amplification of about 10,000 to 1 is available in the device.

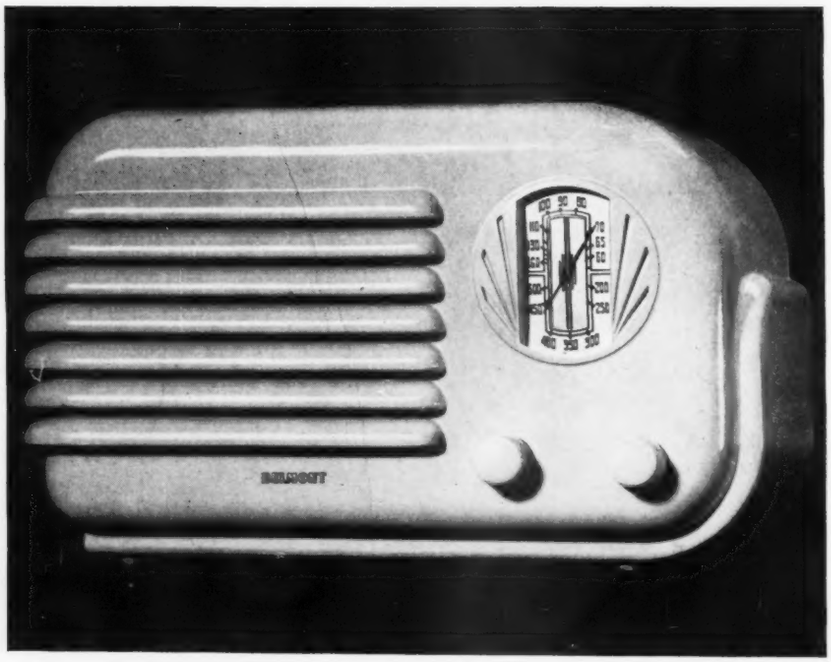
The Amplidyne generator is a motor driven generator of the compensated type which has an extra set of short-circuited brushes for each set of poles. The short-circuited brushes are usually set at right angles to the power brushes. A field winding supplies a control magnetic field which induces a voltage in the short-circuited brushes and at the same time with an over-all amplification of about 100 to 1. This is the first stage of amplification in the device. The control is then transferred

ORIGINAL CLOUD CHAMBER EXHIBITED



Dr. F. A. B. Ward, (right) museum officer at the Science Museum, South Kensington, explaining C. T. R. Wilson's original cloud chamber, which showed the motions of electrons directly for the first time

Here Beauty is more than Skin deep



INSUROK

The Precision Plastic

Surface beauty is not enough—it must be backed by performance. For that reason every INSUROK precision molded part or product not only possesses pleasing appearance but delivers the utmost in utility and dependability. Manufacturers are quick to appreciate these advantages. More and more Richardson facilities are called upon to assist in adding eye appeal, greater salability, and improved performance to numerous diversified products. Quite likely you're missing something by not availing yourself of this service. Why not investigate?

The RICHARDSON COMPANY

Melrose Park, (Chicago) Ill. Founded 1858 Lockland, (Cincinnati) Ohio
New Brunswick, N. J. Indianapolis, Ind.
Detroit Office: 4-252 G. M. Building, Phone Madison 9386
New York Office: 75 West Street, Phone Whitehall 4-4487

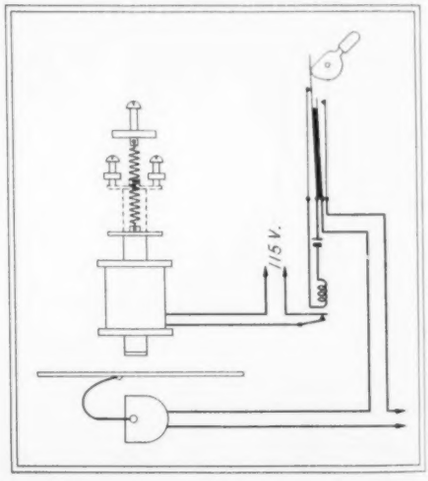
from the short circuited set of brushes to the power brushes, resulting in a further gain of 100 to 1 or 10,000 to 1 overall.

Several installations of the Amplidyne type generator have already been made, particularly in the steel industry. For example, one such generator has been used in conjunction with a boring mill as a means of obtaining rapid and accurate positions of the cutting tool. The operator pre-sets the position of the next cut to be made by dials which indicate feet, inches, and thousandths of inches. These dials in turn control the input to the Amplidyne generator which positions the tool to the displacement indicated on the dials when the operator presses a button. The next cut is then made. The device has also been used as a means of controlling the speed of reeling of continuous steel strip as a means of obtaining constant tension and uniform speed in strip polishing, as a means of synchronizing flying shears and as a means of excitation of large synchronous motors. It has also been used in the paper industry to allow production of both light and heavy grades of paper with a minimum of waste. Also, in conjunction with photoelectric registering devices it is possible to maintain the exact register of paper moving through rewinding.

• • •

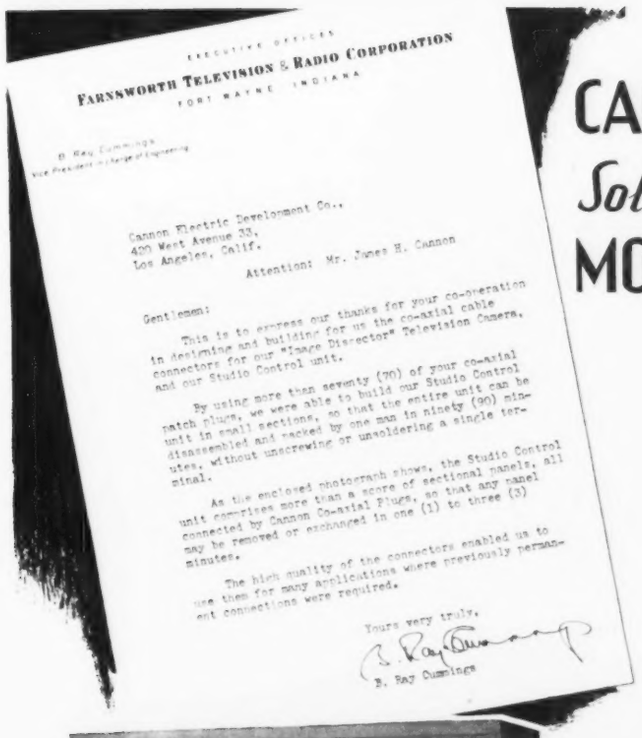
A Simple Chime for Station-Breaks

THE EDITORS ARE indebted to A. G. Swan of Station WRGA for information on a simple chiming device for use in broadcast stations. The ordinary hand-operated chime must be placed close to the microphone if it is to offer sufficient level relative to the rest of the program, and if this is done, the noise of the hammer is apt to be objectionably loud.



Arrangement of station-break chime

To eliminate this trouble, a simple electrically-operated chime pick-up device was installed in the control room of the station, and was arranged for operation from the announcer's posi-



EXECUTIVE OFFICES
FARNSWORTH TELEVISION & RADIO CORPORATION
FORT WAYNE INDIANA

B. Ray Cummings
Vice President in Charge of Engineering

Cannon Electric Development Co.,
420 West Avenue 33,
Los Angeles, Calif.

Attention: Mr. James H. Cannon

Gentlemen:

This is to express our thanks for your co-operation in designing and building for us the co-axial cable connectors for our "Space Director" Television Camera, and our Studio Control unit.

By using more than seventy (70) of your co-axial patch plugs, we were able to build our Studio Control unit in small sections, so that the entire unit can be disassembled and packed by one man in ninety (90) minutes, without unscrewing or unsoldering a single terminal.

As the enclosed photograph shows, the Studio Control unit comprises more than a score of sectional panels, all connected by Cannon Co-Axial Plugs, so that any panel may be removed or exchanged in one (1) to three (3) minutes.

The high quality of the connectors enabled us to use them for many applications where previously permanent connections were required.

Yours very truly,

B. Ray Cummings

B. Ray Cummings

CANNON *co-axial* CONNECTORS *Solve Problem In Construction of* MOBILE TELEVISION UNIT...

WHEN Farnsworth Television & Radio Corporation decided to build certain Television equipment to assist in spreading the fame of their Television set throughout Uncle Sam's domain, came the problem of mobility * * * which called for the construction of the master unit in smaller sections to be quickly, yet efficiently, assembled and disassembled for packing and transport on the proposed nation-wide tour.

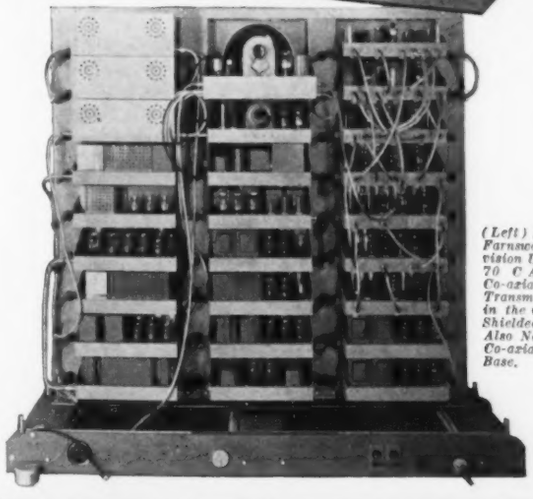
With sectional construction clearly indicated, the problem focused itself on positive, efficient connections for numerous short-length, co-axial cables between sections. The solution likewise was clear —Co-axial Plugs for complete shielding of every circuit. And since the name "Cannon" was synonymous with "Plugs", Cannon engineers soon were at work designing a rugged Co-axial jack with the efficiency of a solder terminal. Just how well they met this challenge we leave to the words of Farnsworth's Mr. Cummings in the letter above.

Farnsworth Mobile Television Transmitter, Assembled in Sections and Equipped Throughout with CANNON Co-axial Cable Connectors.

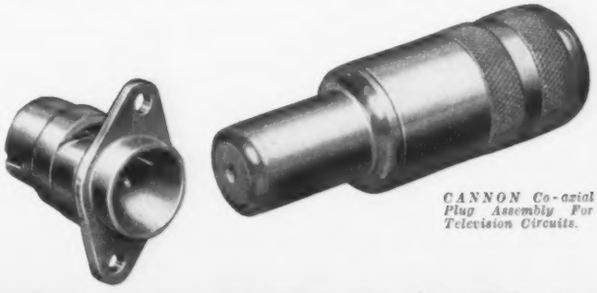
Over 70 Co-axial Jacks and panel-mounting, mating Receptacles are employed for connection and quick disconnection of more than a score of shielded circuits * * * * "This equipment", writes Vice-President Cummings further, "together with the parts which Cannon supplied for it, has given and continues to give excellent service after exhibits in 25 or 30 of the larger cities . . .".

The development of these Co-axial Plugs for Farnsworth illustrates the highly specialized service available to Cannon clients. CANNON Cable Connectors are pre-eminent in the fields of Sound, Aeronautics, Geophysical Research, Instrument-Control on Ships and Laboratory Panels.

Illustrated Bulletins with dimensional data describe various CANNON lines. Please specify your requirements when requesting Bulletins.



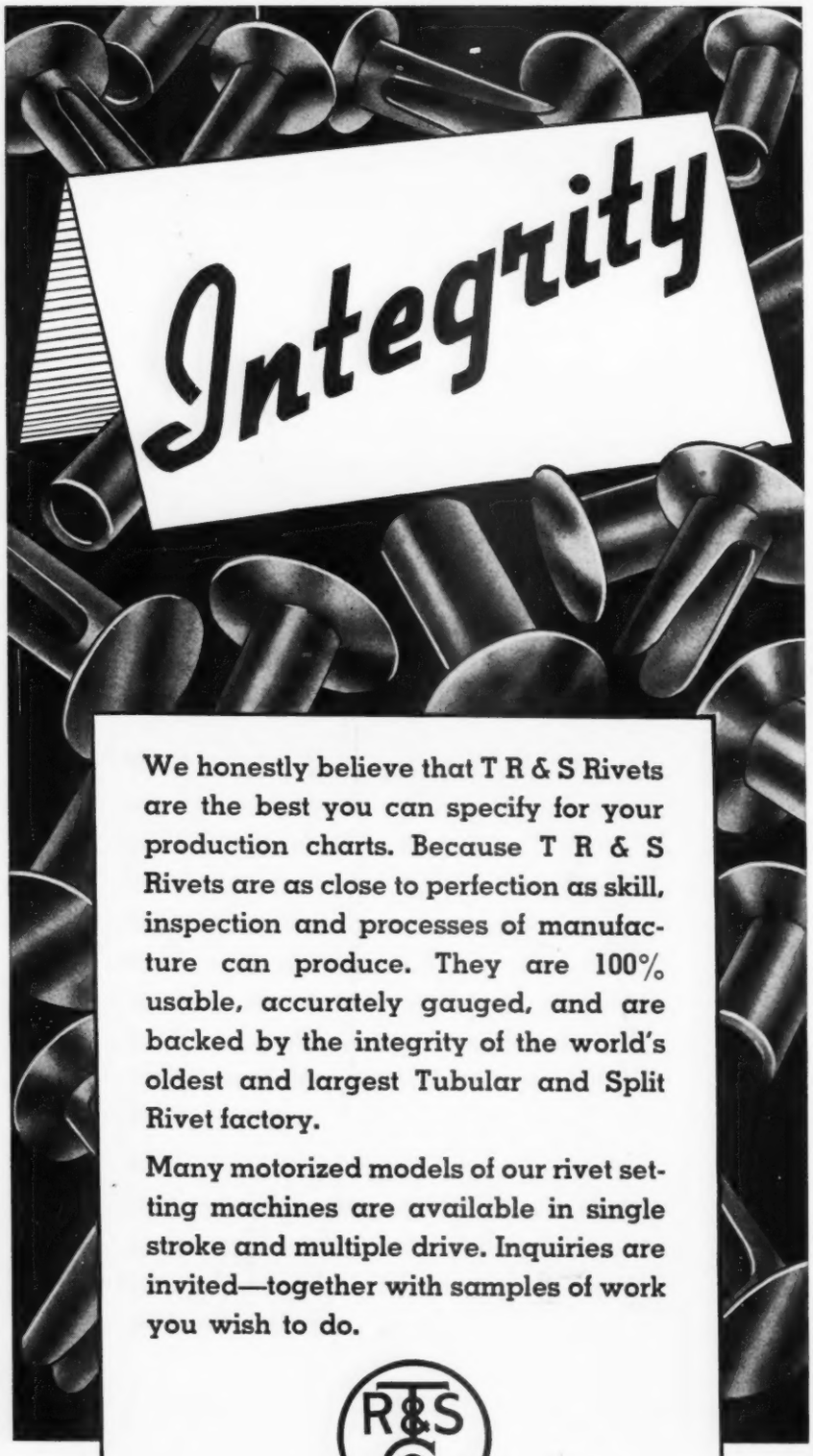
(Left) Rear View Farnsworth Television Unit. Over 70 CANNON Co-axial Plugs Transmit Current in the Completely Shielded Circuits. Also Note Larger Co-axial Plugs In Base.



CANNON Co-axial Plug Assembly For Television Circuits.

CANNON ELECTRIC DEVELOPMENT COMPANY
420 WEST AVENUE 33 LOS ANGELES, CALIFORNIA
Eastern Sales Office: 220 Fifth Ave., New York, N. Y.

CANNON PLUGS



We honestly believe that T R & S Rivets are the best you can specify for your production charts. Because T R & S Rivets are as close to perfection as skill, inspection and processes of manufacture can produce. They are 100% usable, accurately gauged, and are backed by the integrity of the world's oldest and largest Tubular and Split Rivet factory.

Many motorized models of our rivet setting machines are available in single stroke and multiple drive. Inquiries are invited—together with samples of work you wish to do.

R&S C

TUBULAR RIVET & STUD CO.

World's Largest Manufacturers of Tubular and Split Rivets

WOLLASTON (Boston) MASSACHUSETTS

New York Chicago Detroit Indianapolis
San Francisco Nashville Dallas St. Louis

tion. A simple key at the announcer's position closes a relay in series with 115-volt circuit, which feeds the electrically-operated chime. Chimes of this type may be obtained from hardware stores. A simple wire connection between the tone bar of the chime and the needle receptacle of a standard phonograph pick-up is used to transform the mechanical vibration into an electrical signal.

The key at the operator's position is so connected that the pick-up circuit is opened when the chime solenoid is put into the circuit. This disconnects the pick-up during the initial striking of the hammer. When the key is released the pick-up is connected to the circuit and delivers the tone to the amplifier input.

• • •

Atom Smasher Displayed at East Pittsburgh

THE HIGH VOLTAGE generator and atomic bombardment apparatus which has been under construction at the Westinghouse Research Laboratories was recently demonstrated to technical writers and educators by Dr. E. U. Condon, associate director of the laboratories. The demonstration showed how artificial radioactive substances may be produced by proton (hydrogen nuclei) bombardment. The fluorine in natural fluorite was transformed into neon by bombardment. In this case the fluorine atoms capture protons and assume the next higher atomic number, that of neon. The transformation is accompanied by the production of gamma radiation. In another demonstation, ordinary carbon in graphite form was bombarded by one microampere of current of deuterium (heavy hydrogen ions) for 15 minutes. The result was the production of radioactive nitrogen, equivalent in activity to 10 milligrams of radium.

The high voltage generator demonstrated by Dr. Condon (left)

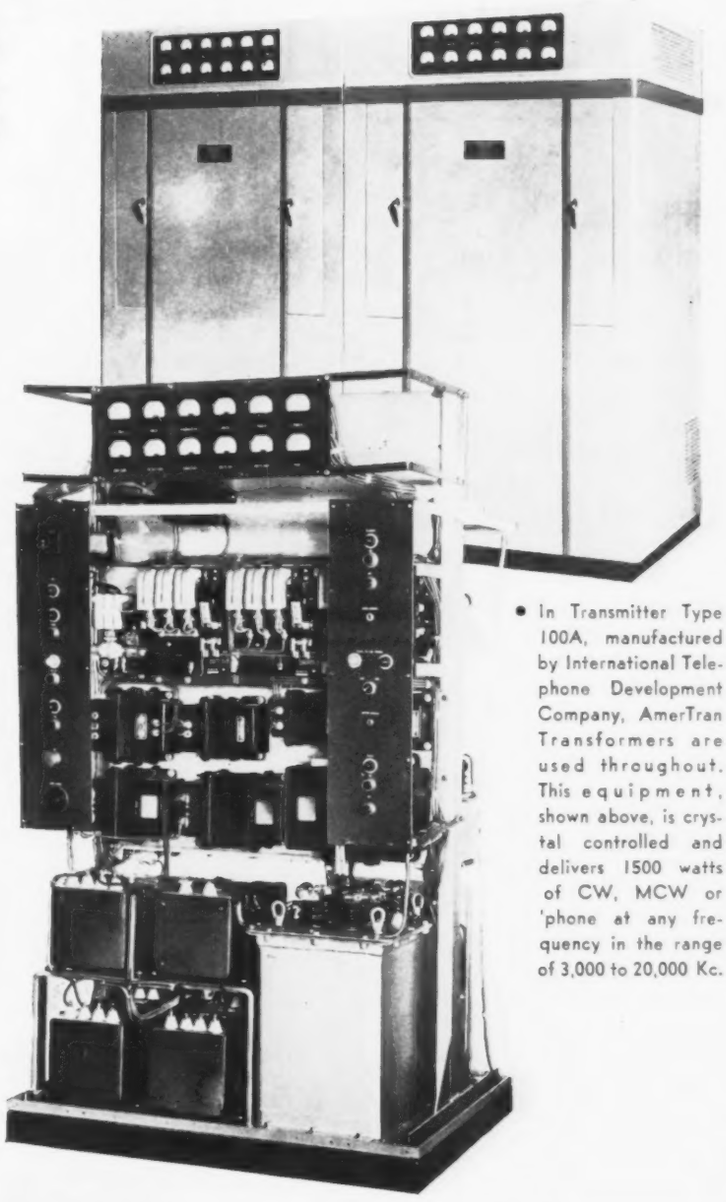
After 10 years—

AmerTran Transformers are still selected by leaders in industry for all electronic applications.

Since the first issue of "Electronics," back in 1930, AmerTran advertisements have featured transformers for electronic applications. At that time AmerTran was already the acknowledged leader in this specialized field, having had experience extending over three decades in supplying transformers to the communication industry.

Today AmerTran's position is unchanged and leaders throughout the entire electronic industry continue to specify our equipment for transformer applications. Apparatus regularly supplied covers the complete range—from the smallest audio unit of an air-craft receiver to the giant power transformers for a 50,000 watt transmitter—and all ratings are available in either small or large quantities.

Let us submit complete data on transformers for your particular requirements.



• In Transmitter Type 100A, manufactured by International Telephone Development Company, AmerTran Transformers are used throughout. This equipment, shown above, is crystal controlled and delivers 1500 watts of CW, MCW or 'phone at any frequency in the range of 3,000 to 20,000 Kc.

TENTH ANNIVERSARY

AMERICAN TRANSFORMER CO.

178 Emmet St. Newark, N. J.

• Coordination in transformer designs explain the excellent performance characteristics of Transmitter Type 100A. At 85 percent modulation, the transmitter output is uniform within 2 percent with harmonic distortion below 3 percent.

AMERTRAN

Manufactured Since 1901

at Newark, N. J.

S. S. WHITE FLEXIBLE SHAFTS have gone places since 1930

Of course, S. S. WHITE Flexible Shafts were well known and widely used long before 1930. But during the 10 years since then, applications have multiplied at a rapid rate. This has been particularly true in the automotive, aviation and electronic fields, due mainly to the origination and development by S. S. White of **Remote Control** shafting specially for radio and other applications in these fields.

A FEW APPLICATIONS OF S. S. WHITE SHAFTS

AUTOMOTIVE

Auto Radios—panel and underseat
Radio Antennas
Clock Setting
Trip Mileage Reset
Choke and Needle Valve
Engine Governor
Search Light
Gear Shift
Heaters
Air Conditioning
Taximeters
Truck Recorders
Speedometers
Windshield Wipers
Automatic Carburetor

AIRCRAFT

Radio Receivers
Beacon Receivers
Compass Loop
Antenna Loop
Antenna Reel
Heating Register
Tab Control
Turn Bank Indicator and Bomb-Sight
Tachometers
Fuel Pumps
Controllable Pitch Propeller Governors

If you are not familiar with these latest flexible shaft developments, Bulletin 1238 on Power Drive Shafts, and Bulletin 38 on Remote Control Shafts, will bring you up to date. Copies are yours for the asking. Write for them.

S. S. WHITE

The S. S. White Dental Mfg. Co.

INDUSTRIAL DIVISION

Department E, 10 East 40th St., New York, N. Y.

FLEXIBLE SHAFTS for POWER DRIVES, REMOTE CONTROL and COUPLING

The atom-smashing apparatus consists of a high-voltage generator of the moving-belt (van der Graff) type which has been used at direct voltages as high as 4,000,000 volts. The constancy of the voltage produced, important in controlling the atomic transformations, is greater than that of any high voltage machine yet developed. Experiments to determine the minimum energy required to produce neutrons from lithium and carbon under proton bombardment are now under way.

• • •

X-Ray For Checking Condition of Automobile Tires

RAPID INSPECTION OF automobile tires without removal from the car or truck is made possible by a new portable X-ray device developed by the General Electric X-Ray Corp. The unit is intended to reveal the presence of tacks, nails, wire, etc or glass or stones embedded in the tire wall. It can accomodate tires of all passenger cars and of the smaller trucks, including white-wall tires which contain zinc oxide and hence are more opaque to X-radiation than is the ordinary tire. Inspection is made by means of a fluoroscopic viewing screen.

The X-ray tube itself is mounted in an all-metal head which includes all the high-voltage parts (transformers and tube) immersed in insulating oil. The construction resembles that of the standard shock-proof mounting used widely in industrial and medical practice. The unit is energized from a standard 110-volt 60 cps line. Two switches are provided: one is a lock-type line switch which can be operated only by authorized persons, and the other, a push-button switch, applies the high voltage to the X-ray tube as desired. Two values of anode voltage are available, which may be selected by a two-position selector. The higher voltage rating is used only on the thicker tires.

In use, the X-ray unit is wheeled under the car, which has previously been jacked up until the wheels are about 9 inches above the floor. The head of the machine is placed directly under the axle and close to the tire but not touching it. A handle is then turned which clamps the wheels of the X-ray unit, raises protective shields on either side to inhibit stray radiation, and places a roller against the wheel to turn it slowly past the X-ray head. The operator then presses the high voltage switch and views the tire through the fluorescent screen hood. The tire is turned by the roller, which operates under the control of the operator. When a foreign object is discovered, its exact position may be determined by slowly turning the wheel until the X-ray image of the object falls directly opposite a reference arrow marked on the screen.

DEPENDABLE TUBES

DEPEND UPON WESTINGHOUSE

There are no "degrees" of quality in Westinghouse Radio Transmitting tubes. Each must come up to the same high standards inherent in all Westinghouse products. These standards are guaranteed to us—and to you—by specified controls and tests at every stage of manufacture, from raw materials to finished tube.

For example, Westinghouse filament wire is completely manufactured within our own plant, with every step of processing controlled by exacting specifications. Filament wire for Westinghouse tubes must run the gauntlet of more than 100 quality checks during its evolution from acceptable ore to quality wire.

This is typical of the care and attention which we give to all phases of tube manufacture, and which permits us to say:

For dependable tubes depend upon Westinghouse

Write for descriptive tube bulletin TD-92
Westinghouse Special Products Division, Bloomfield, New Jersey

A new 50 KW transmitter with special advantages for commercial broadcasting

Hand in hand with development of radio tubes and practical operation of commercial Stations such as KDKA, Westinghouse has applied pioneering radio experience to the development of improved broadcasting equipment.

A new 50 KW transmitter, already in daily operation at Station KDKA, provides (1) Air cooling of all tubes, (2) Clean-cut modern design with every part readily accessible, (3) Fuseless protection for all circuits, (4) Extremely low operating cost.

Complete details on request: Westinghouse Radio Sales Division, Baltimore, Md.

TUNE IN WESTINGHOUSE "MUSICAL AMERICANA", N. B. C. BLUE NETWORK, THURSDAYS, 8 P. M., E. S. T.

THE FIRST NAME IN RADIO BROADCASTING

WESTINGHOUSE KDKA
The Station That Pioneered All Radio Broadcasting

RADIO WIRES have "PERSONALITY" too

Belden Hook-up Wires —approved HR Wires

Meet definite performance specifications for every manufacturing need.

Belden Microphone Cables engineered to meet particular requirements

Provide great flexibility, unusual tensile strength, and long life. Specially developed shielding and low capacity rubber. One or many conductors—for all types of microphone and control circuits and test instruments.

Belden Magnet Wires for more efficient coils

Beldenamel, Cotenamel, Silkenamel, Celenamel—paper covered—and many specially insulated types including Formvar. Belden standards assure softness and uniformity and over-all manufacturing economy.

It's easy to identify the best wire for each job

Belden wires are engineered to fit the radio industry's most exacting requirements. Belden wires in production are subjected to the most detailed inspection to obtain constant characteristics.

These wire characteristics are known. You can specify hook-up wire to such specifications as Power Factor, Q-Value, Puncturing Voltage, or Insulation Resistance, as well as size, color, and insulation.

You can specify microphone cable of known capacity between conductors and between conductors and shield. You have equal confidence in quality and uniform characteristics of every item in Belden's complete assortment of wires for radio and sound equipment manufacturers. Use the right wire for every job. Specify Belden.

Belden Manufacturing Co., 4625 W. Van Buren St., Chicago, Ill.

"Don't Go Haywire" Go **Belden**

WIRES FOR RADIO AND COMMUNICATIONS

Which Resistor?

TENTH ANNIVERSARY

Your resistor requirements are no more difficult to fulfill than those of more than 10,000 Electrical and Industrial Engineers who are now using these bulletins as a reference guide.

Vitrohm Resistors, designed to satisfy these 10,000, are available in a wide variety of sizes, ratings and terminals. Your "special" problems can be solved by these combined standard Ward Leonard Resistors.

Send for these bulletins. You will find them most useful and helpful guides in solving your resistor problems.

BULLETIN 11

Tells about Vitrohm Wire Wound Resistors, gives sizes, watt ratings.

BULLETIN 19

Describes Ward Leonard Ribflex Resistors for unusually heavy duties.

BULLETIN 25

Is a treatise of standard and special mountings and enclosures.

WARD LEONARD
ELECTRIC COMPANY

32 South Street **Mount Vernon, N. Y.**

Electric Control Devices Since 1892

WARD LEONARD ELECTRIC CO., 32 South Street, Mount Vernon, N. Y.

Please send me your bulletins Nos......

Name .....

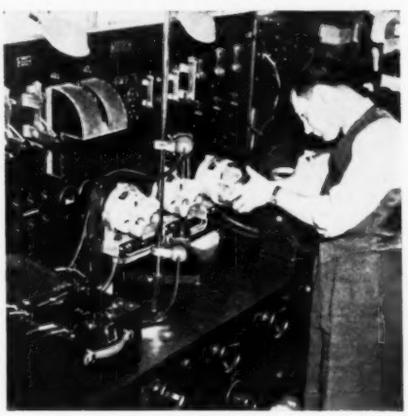
Company .....

Street .....

City..... *State*.....

Phototube Counts Revolutions of Watthourmeter, Compares It With Standard Unit

A new photoelectrical method of testing the calibration of revolving-disc type watthourmeters has been developed at the G.E. Laboratories at Schenectady. The phototube system employs a source of light on one side of the revolving disc of the meter under test and a phototube on the opposite side. Light passes though the "creep-holes" in the disc, registering a count twice



Light-source and phototube (on standard) count watthour revolutions

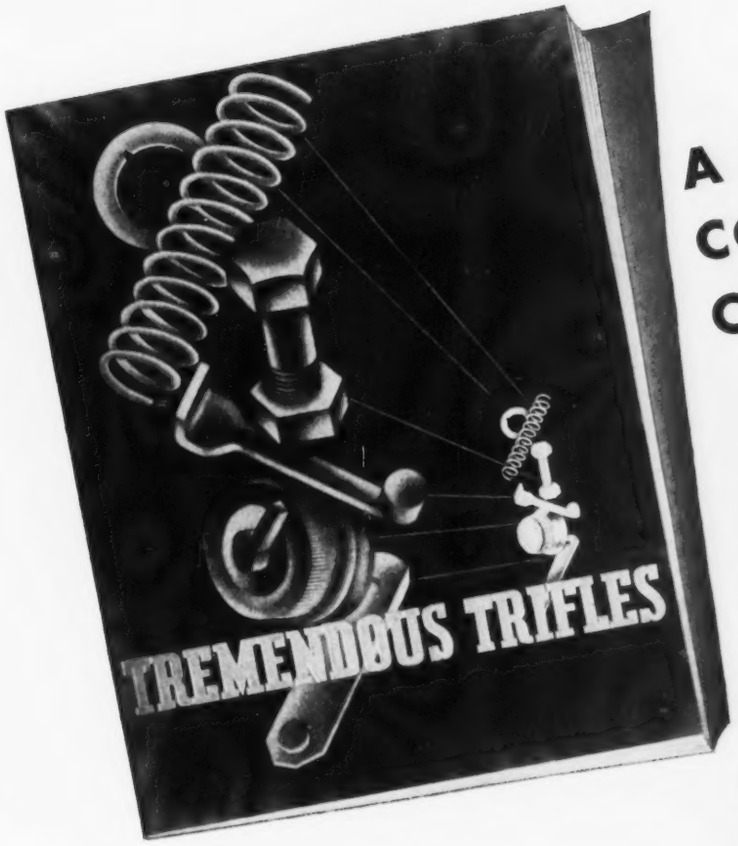
in each revolution. The phototube current passes to an amplifier and relay system which applies voltage to the potential circuit of the rotating standard meter, thus allowing the rates to be compared directly. Tests show that the accuracy of the comparison is within 0.004 per cent in one revolution and 0.0004 per cent in ten revolutions. This high degree of accuracy allows a much shorter running time in each test, approximately one half the time needed in the conventional counting method.

• • •

Britain Plans Television Via Cable

PLANS HAVE BEEN prepared for reopening the television service in Great Britain which was interrupted by the outbreak of war. The new arrangement is to make use of relay stations and low loss cables for transmission purposes and was experimented with by Post Office engineers before the war.

It is claimed that the new plan has certain advantages over the radio-link scheme of distribution from a central point. Chief amongst these are freedom from interferance and low monetary cost, as neither the British Broadcasting Corporation nor the Government would be required to contribute anything to the finances of the scheme. The Postmaster General and his technical experts are at present considering the proposals.



A 16-PAGE COLLECTION OF MONEY MAKING IDEAS

Tells how well-known Electrical Equipment manufacturers improve small parts and make a good product better

ARE you bothered by a spring that fails at high temperature . . . or a vibrating part that fails through fatigue? For these and countless other metal problems you'll find a ready solution in Inco's new booklet, "Tremendous Trifles."

This new booklet is *practical* from start to finish. The ideas it presents are *successful*... worked out by manufacturers, as shown in the list at right. In addition, "Tremendous Trifles" contains a valuable section of Condensed Engineering Data, by which you can *compare the properties* of metals and alloys used for electrical and electronic applications.

Because of the expense of publishing this booklet, it is being mailed only on request. In reply to a single letter, 1992 electrical equipment makers have already sent for a copy. Would *you* like to have one? Then simply return the attached coupon . . . no charge and absolutely no obligation.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 WALL STREET, NEW YORK, N. Y.

INCO MONEL

"Monel" is a registered trade-mark of The International Nickel Company, Inc., which is applied to a nickel alloy containing approximately two-thirds nickel and one-third copper.

MONEL

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Read why Monel and other Nickel-base alloys were selected by the following and other manufacturers:

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Gentlemen:

Please send me without charge or obligation a copy of your new booklet, "Tremendous Trifles."

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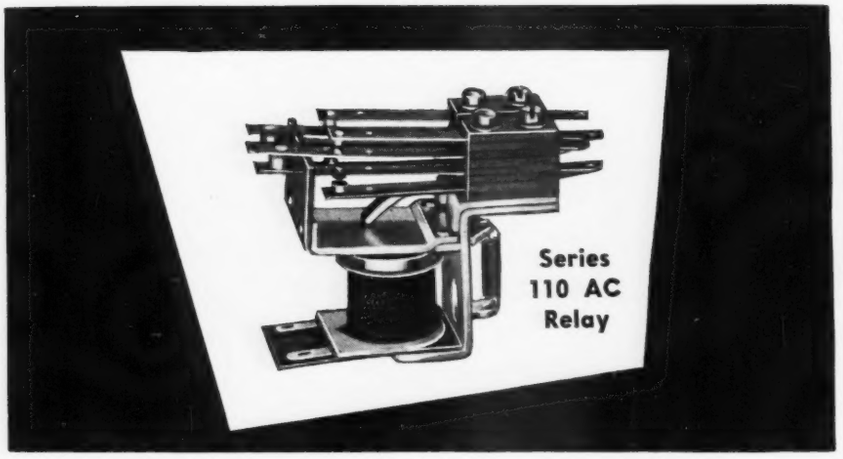


TIME TESTED AND PROVED—A SMALL RELAY FOR GENERAL APPLICATIONS

★ Bring your control problems to Guardian Electric where experience gained through the design, development and production of thousands of electrical control units—from simple small relays like the well-known Series 110 AC Relay by Guardian illustrated above—to intricate combinations—can turn your seemingly impossible control problems into quick, easy answers.

RELAYS BY GUARDIAN

Designed singly, or in complete control assemblies from 3700 standard Guardian parts—synchronized each to the other and to your machine. High speed production lines turn out ANY QUANTITY AS YOU WANT THEM WHEN YOU WANT THEM—with a plant within a plant to produce those one, two or three control units you must have now.

Quantity control orders produced in three days time. Faster if necessary, with overnight shipping service to every industrial center.

Ask Us To Make Specific Recommendations. Write

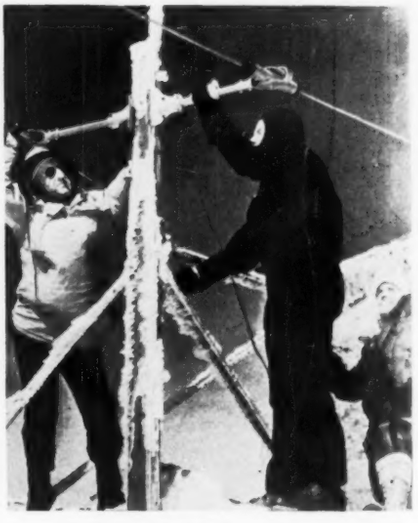
GUARDIAN ELECTRIC

1625 West Walnut Street **Chicago, Illinois**

Easter Telecasts Observed by Weather Observation Staff at Whiteface Mountain, N. Y.

IN ONE OF THE LONGEST distance television relays ever reported, the staff of the weather observation station at Whiteface Mountain, 4872-feet high in the Adirondacks and 250 airline miles from the original program source, successfully picked up the telecast of the Easter Services and Fifth Avenue parade telecast from the N.B.C. Empire State transmitter. The weather station is maintained jointly by Rensselaer Polytechnic Institute and New York University. The reception covered two jumps, 130 miles from New York to the G. E. station, and another 120 miles to the mountain top. Snowshoes and toboggans were used to transport the aerial and a standard table model receiver over five miles to the weather station.

Prof. Corwin of R. P. I., K. G. McCaslan, weather observer, Joseph Wiggin, G. E. engineer, Willard Cody, chief observer and Ken Williams, cook, view the Easter ceremonies in New York



Messrs. Cody, Wiggin, and Corwin erect the television antenna in a 77-mile wind atop the weather observation station

TENTH ANNIVERSARY

AMONG the many types of laminated phenolic sheet supplied for electrical insulating purposes by Formica, is one, XPND33, that was developed especially to provide fast easy punching for production purposes . . . Intricate shapes can be punched cold from this material up to 5/64 in thickness with a clean edge and a minimum of surface cracking between the holes. Simple shapes may be punched up 1/8 thickness cold . . . The workability of the sheet is combined with insulating qualities that make it suitable for a great many purposes. With it you can get good insulating parts at lower costs.

FORMICA

THE FORMICA INSULATION CO.
4658 Spring Grove Avenue • Cincinnati, Ohio

The Climax
to a decade of electrolytic condenser progress

Special octal base designed and made by AEROVOX, but fits the usual standard octal socket.

●

Nickel-plated brass prongs engage with similar metal socket contacts.

●

Junction of brass prongs and aluminum studs imbedded in molded bakelite, immune to corrosive effects.

●

Hi-purity aluminum tabs from electrolytic section, bonded to aluminum studs of octal base, for corrosion-proof aluminum-to-aluminum joints.

●

Hermetic sealing achieved by can edge spun over soft rubber gasket and bakelite plug. Vented cover for full protection.

●

Available with plain foil and etched foil of highest purity. Two can sizes: 1¾" and 1-5/32" dia. 2½ to 4½" high. Single, dual, triple, and quadruple section units. 25 to 500 v. D.C.W.

● To ELECTRONICS' Tenth Birthday party, we bring a brand new, startling, far-reaching contribution to the radio and allied arts, in the form of the AEROVOX Series AP Plug-In Electrolytic Condenser.

Developed primarily for the U. S. Signal Corps, and for use in aircraft, police radio, sound-system and other equipment where continuity of service is a prime requisite, this idea opens up untold possibilities. Readily removed, tested, replaced, these octal-base condensers handle as easily as a radio tube or vibrator. Assemblies can be equipped with fresh plug-in electrolytics immediately prior to shipment or actual use. Users can have "spares" on hand.

The many problems encountered in providing a tight, leak-proof, hermetically-sealed octal base, together with positive elimination of corrosion, have been fully solved. A perfected, practical, brand new class of condenser, is now available to you.

TENTH ANNIVERSARY

Ask for DATA . . .

Engineering data on this Series AP AEROVOX Plug-In Electrolytic Condenser will be sent on request. Also samples, specifications, quotations, to responsible parties.

AEROVOX CORPORATION
New Bedford, Mass.
Sales Offices in All Principal Cities

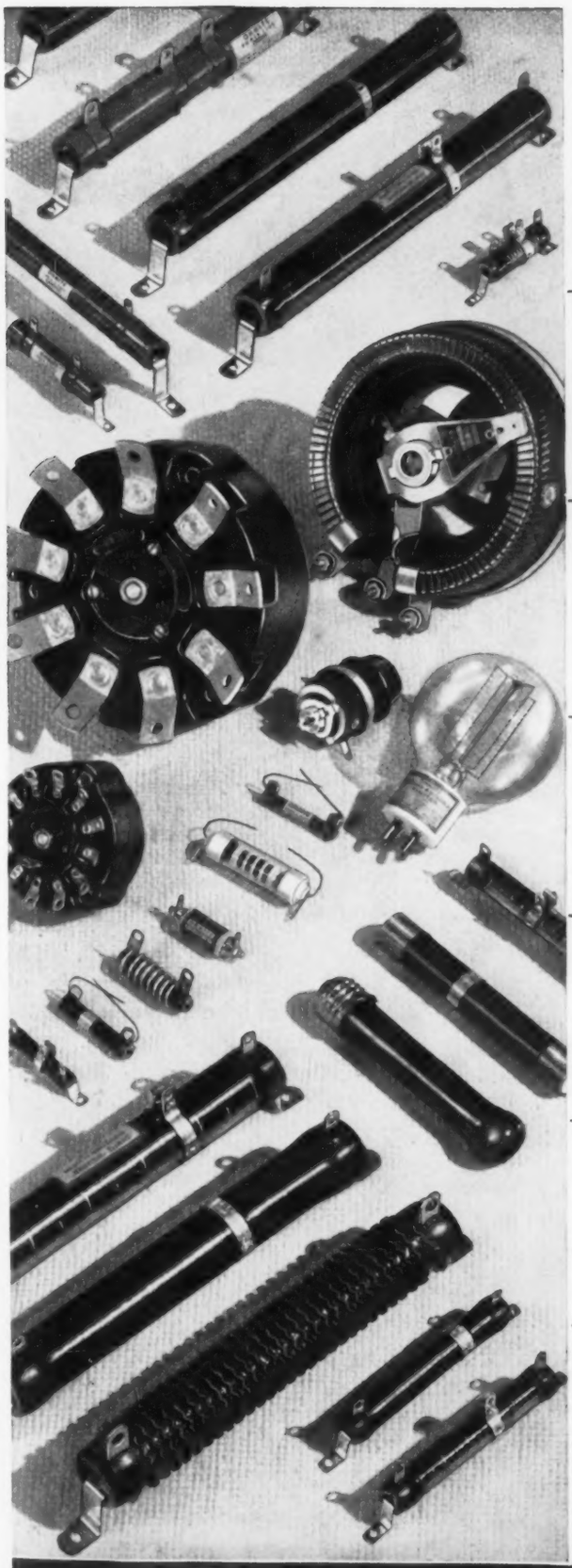
Television Equipment in Transport Plane Relays Pictures to NBC Audience

ON MARCH 6, a notable television broadcast was made using the new portable transmitting equipment recently developed by RCA Manufacturing Company in Camden. The equipment, including two iconoscope cameras, all synchronizing signal generation equipment, and a transmitter operating on 288 Mc, was installed in a United Airlines transport plane, and flown over New York City. A receiver relayed the 288 Mc signals to the N.B.C. Empire State transmitter which rebroadcast the program to the New York area on 44–50 Mc. Another transport plane, equipped with a standard television receiver, accompanied the transmitting plane. Observers in the second plane were able to view the plane in which they were flying, as picked up by the cameras and relayed to them.

The total weight of the equipment including cameras, gasoline driven generator, picture transmitter and sound transmitter and all auxiliaries weighed 1500 pounds. The picture equipment itself weighs 550 pounds when equipped with one camera chain, 850 pounds with two chains and 1050 pounds with three chains, less the weight of the interconnecting cables. The television camera cables are of new design, measuring only an inch in diameter and weighing 0.6 pounds per foot. However, if long cables are used (not necessary in the plane of course), the weight of the cable can become appreciable. In fact, if three cameras are used with 500-foot cables on each, the weight of the cable exceeds that of the equipment. The r-f transmitter, which operates in the frequency range from 275 to 325 Mc weighs 250 pounds, and has a peak power of from 25 to 35 watts, depending on the frequency of operation. The transmission during the flight occured on 288 Mc with about 35 watts peak output.

The television signal equipment itself is mounted in seven packing cases which can be handled by one or two men. In fact, for simple outside broadcasts it is possible for two men to load all the necessary equipment into a station wagon and cover outside broadcasts without further help.

The pictures in the airplane demonstration were picked up by the new small-size iconoscope cameras. In the main the received images were clear and steady, at best about equal in quality to the images produced from the mobile unit trucks currently used for the N.B.C. outside broadcasts. Loss of signal as the body of the plane came between the transmitting and receiving antennas, and some interference from noise and diathermy were occasionally effective in blotting out the picture, but in the main the demonstration was a pronounced success. The route of the plane included the take-off at La-Guardia airport, a flight over the



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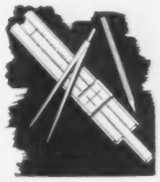
Helps you 5 ways!

Engineered for Your Needs



Our application engineers, with specialized experience in resistance control for all types of applications, will work out the exact, most economical units for your requirements. Just put your problem up to Ohmite.

Many Stock Units for Quick Delivery

You'll find our extensive range of stock types and sizes a great convenience in obtaining economical units quickly. We maintain the largest, most complete stock of close-control Rheostats, wire-wound Resistors, and high current Tap Switches in the world—available for immediate shipment.

Built Right in Every Way

You get many constructional advantages in Ohmite all-porcelain vitreous-enameled Resistors, smooth-action close-control Rheostats, compact Power Tap Switches, and other Ohmite units. They're time-tested, time-proved.

Trouble-Free Performance

There's extra dependability in every Ohmite product to insure continuous, trouble-free performance on the toughest jobs in every kind of climate from the heat and humidity of the tropics to the icy cold of the arctic.

Prompt and Certain Shipment

You are sure of prompt production and delivery on the units you need. Your order is acknowledged with a definite shipping date, and this shipping promise is faithfully kept.

Write for Catalog 17 *It contains handy information about Ohmite Rheostats, Resistors, Tap Switches, R. F. Chokes and Attenuators.*

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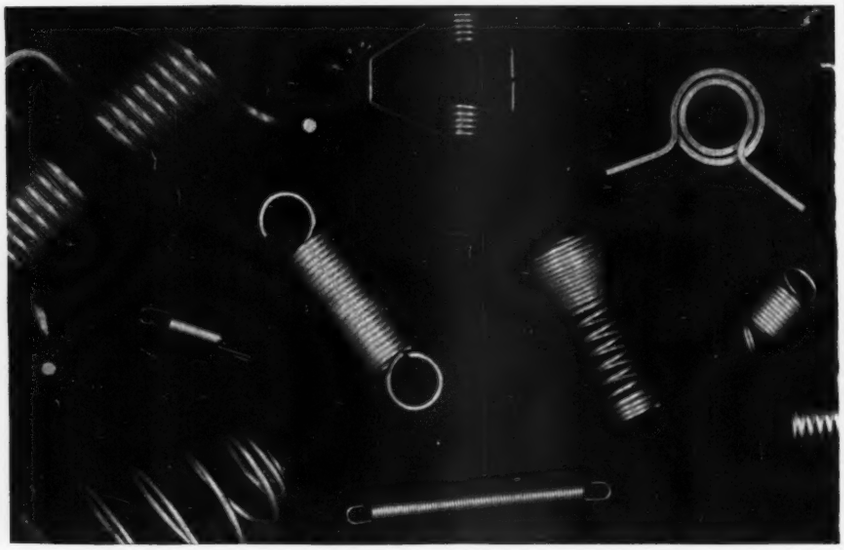
Be Right with OHMITE

RHEOSTATS ★ RESISTORS ★ TAP SWITCHES

HUNTER *Springs*



Compression — Extension — Torsion — Flat

MATERIALS—Springs of all metals. Materials purchased only from approved sources working to Hunter specifications. A complete range of sizes of all spring materials carried in stock to insure prompt delivery. Each lot of material is test inspected before acceptance.

DESIGN AND SPECIFICATIONS—Engineering department of capable and experienced personnel determines in advance the proper size, type and design of spring to meet each customer's requirements and thereby insures correct performance of springs.

PRODUCTION equipment includes modern automatic coilers for wire sizes .004" to .250" diameter. Other equipment produces springs up to a maximum wire size of .625" diameter. In addition to 4-slide and high speed presses, complete equipment is available for performing all operations incidental to spring manufacture. Small orders are handled by a specially equipped department. Standard finishes available are Pentrate; Japan; Cadmium, Nickel, Copper and Silver Plating.

INSPECTION of production to verify the meeting of physical and test specifications and tolerances. Inspection facilities include load testing equipment with capacity ranging from grams to tons. Rockwell, torsion and magnaflux (seam detection) inspection are used as required.

EXPERIENCE covers twenty years of practical spring making combined with the most advanced engineering practice of spring design. The results are satisfied users of Hunter Springs in over three hundred distinct types of industry.

Stampings

BLANKS, FORMS, DEEP DRAWN PARTS—Light and heavy single action press work—maximum capacity 135 tons. Light four-slide stampings. Light and medium extra deep drawn stampings.

MATERIAL—all metals .004" to .250" thickness. Maximum blank size 15" x 15" x 1/8".

SHORT RUN STAMPINGS — Eliminate higher cost of permanent dies when only small lots of metal stampings are required. Especially helpful in development of models and experimental work, design changes, etc.

TOOLS, DIES AND JIGS—made in our own plant by expert tool makers.

DESIGN—the most economical stampings are designed to meet each customer's requirements. Close tolerances are held. Unusual stampings are our specialty.

EXPERIENCE—covers thirty-five years in the production of stampings including the manufacturing of the Hunter Grease and Oil Cups—a pressed steel product involving intricate problems of deep drawn work. Many of the largest and best known users of high grade stampings have long been our customers.

HUNTER SPRINGS - STAMPINGS

HUNTER
PRESSED STEEL CO.
LANSDALE, PENNSYLVANIA

World's Fair, over the lower Bronx to the Hudson River, the George Washington Bridge, then southward to the skyscrapers in lower Manhattan, including the Empire State building from which the program was rebroadcast. Radio City, Central Park and the Islands in New York Harbor were included in the itinerary.

Technically, the telecast was notable in that the synchronization signals were derived from a totally isolated power source, a light-weight 110-volt generator developed by D. W. Onan and Sons. The 60 cps output of this generator was fairly stable, but far from synchronous with the 60 cps power system on the ground. Despite this, most of the receivers held in synchronism steadily throughout the broadcast. The Empire State transmitter was used simply as a relay link, using the signal from the plane to modulate the transmitter output directly without attempting to tie in the signal with the local synchronizing signals. The gasoline generator has frequency stability of plus or minus one cycle. The plane used was a Boeing Model 247-D used as a "flight research" ship by United Airlines.

The portable equipment was designed to allow outside pick-ups for standard television broadcasts to be made with smaller crews and less involved preparation than are required with the mobile unit trucks. The new equipment has already gone into service in the N.B.C. telecasts.

• • •

HEAR YOURSELF AS OTHERS HEAR YOU

The Voice-O-Graph, being demonstrated recently at a coin machine show in Chicago. The machine is an automatic voice recorder attached to a coin-operated record player. The machine may be switched so that the listener can hear the reproduced voice either through the ear phone, as shown, or through a loud speaker

NATIONAL RESEARCH CREATES NEW PRODUCTS ★ NEW MARKETS

LONG LIVE

Jackson Soldering Pencils

..thanks to

PHENOLITE
REG U.S. PAT. OFF.
Laminated BAKELITE

TENTH ANNIVERSARY

JACKSON Electro Corporation of Brooklyn, N.Y. were having difficulty with the performance of their soldering pencils. This was due to the brittleness and heat transfering qualities of the porcelain bushing used to insulate the wooden handle of the soldering pencil from the hot metallic element.

The porcelain bushing would break . . . the handle would char, quickly resulting in an unusable article. National engineers recommended the use of asbestos base (heat resisting) "Phenolite" laminated bakelite to replace the porcelain bushings. The result: practically indefinite product life . . . widely increased sales.

Whether it is a tiny bushing or a large heavy duty gear, or one of a thousand products, Phenolite is constantly demonstrating its ability to withstand the kind of punishment other materials can't take. And National engineers are demonstrating also their ability to work with industry in the manufacture of better products through the use of Phenolite and National Vulcanized Fibre. We invite your inquiry.

NATIONAL VULCANIZED FIBRE COMPANY

FOUNDED 1873

WILMINGTON DELAWARE

NATIONAL VULCANIZED FIBRE

PHENOLITE Laminated BAKELITE

These NATIONAL Products have a Cost-Cutting Application in your field. We can make it easy for you to select the right product and grade.

FM is here

BROADCASTERS GET READY

Why experiment with unproven tubes? Practically every Broadcast station now on the air with FM uses Eimac tubes

Here's the line up

EIMAC 250T

In service now on Frequency Modulation. Eimac 250T has proven itself to be ideal for all communication and relay services as well as broadcast. Recommended for 250 to 500 watt stations.

Net Price $24.50

EIMAC 450T

In service now on Frequency Modulation. This tube will be most popular for FM broadcasters because it operates very efficiently on 1KW power level. Recommended for 1KW stations.

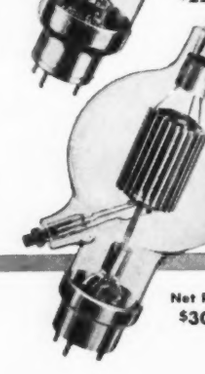
Net Price $75.00

150OT and 200OT

In service now on Frequency Modulation. The answer for higher power broadcast services, providing maximum power and efficiency for 2KW to 10KW stations. All of these Eimac tubes are in actual service in FM transmitters today. Don't experiment with untried tubes... when you install your new FM transmitter insist on

Eimac TUBES

Net Price $225



Net Price $300

For further information write to Eitel-McCullough, Inc., San Bruno, California

FM Before FCC

(Continued from page 16)

ceiver merchandising since the early $300 superheterodynes.

Copies of Major Armstrong's patent-license agreements with broadcast stations transmitter manufacturers and receiver manufacturers were offered for the record. It was revealed that a down payment of about $25,000 was required of a manufacturer, but that this payment was refunded if the manufacturer agreed to spend it in research. Thus far every manufacturer has taken advantage of this arrangement, and only license fees have been collected. Licenses to transmitter manufacturers are three in number: General Electric, Western Electric and Radio Engineering Laboratories. The receiver manufacturers licensed, ten in all, are: General Electric, Hallicrafters, Hammarlund, National Co., Pilot, R. E. L., Scott Laboratories, Stewart-Warner, Stromberg-Carlson and Zenith. Major Armstrong also testified to the amounts he had received from the sales of his previous inventions. The superheterodyne and regenerative patents were sold in one sale for $330,000; the superregenerative circuit for $425,000. The cost incurred by Armstrong in developing frequency modulation to date was given as "between $700,000 and $800,000".

John Shepard Testifies for F-M Broadcasters

The first witness for F-M Broadcasters, Inc. was its president John Shepard, III, of the Yankee Network. He stated that some 55 of those broadcasters who have licenses, construction permits, or applications for f-m permits comprise the membership of the association, and that membership is open to any such broadcaster. Mr. Shepard presented eleven resolutions for the membership of the association, ratified by it on March 17th, just before the hearing opened. The resolutions are as follows:

I: The granting of regular licenses for fm instead of experimental licenses be requested.

II: The Commission be requested to raise the power limitation on f-m transmitters from 1 kw to 50 kw.

LENZ *Presents*
a NEW and IMPROVED
DIAL LIGHT SOCKET

Voltage Breakdown between contacts—1200 Volts.
Voltage Breakdown to ground—5000 Volts.

Bakelite Shell is recessed for contacts, which cannot be pushed or pulled out of position.

Heavy wall Bakelite Shell.

Brackets on grounded type socket welded to shell preventing interference due to vibration.

Tensile strength of leads and connections far in excess of requirements.

Center contact mounted so that it cannot protrude from shell and short on chassis when lamp is removed.

Lug on contact fits in groove in shell so that contact cannot be turned or twisted when inserting lamp.

A variety of different mounting bracket styles available, suitable for practically any mounting.

• *Complete Wire and Socket Assembly Accepted in Radio Receivers listed by Underwriters Laboratories.*

The superiority of the new Lenz Dial Light Socket, both electrically and mechanically is apparent with even the most casual inspection.

But even with its obvious superiority the use of the New Lenz Dial Light Socket will not add to the cost of your radio chassis. Samples will be gladly submitted upon receipt of specifications. Lenz Dial Light Sockets are made in both the two wire insulated type with bakelite shell and the single wire grounded type with metal shell.

LENZ

LENZ ELECTRIC MANUFACTURING CO.
1751 N. Western Ave., Chicago, Illinois

ENJOYING ITS 35TH YEAR OF SUCCESSFUL BUSINESS

THE AMOUNT of power a tube will handle depends largely on the ability of the anode to dissipate the heat of operation

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Graphite has higher radiating emissivity and higher thermal conductivity than any other commonly used anode material —therefore, will radiate a greater amount of heat from a given area.

For use as oscillators, amplifiers, doublers, modulators and rectifiers, choose tubes that have SPEER Graphite Anodes —99.9% pure electro-graphite. SPEER Processed Graphite Anodes have highest thermal emissivity, improved degassing qualities, avoid leakage and leakage trouble. List of manufacturers of tubes with SPEER Graphite Anodes, and booklet containing complete data on request.

PROPERTIES OF SPEER GRAPHITE ANODES

THERMAL CONDUCTIVITY 1.92

RADIATION EMISSIVITY (% Emissivity - Black Body = 100%) **95% at 750° C.**

RELATIVE HEAT DISSIPATING VALUE at 510° C.

Graphite 1.00	Molybdenum 0.24	Nickel No. 1 0.025
Tungsten 0.30	Tantalum 0.22	Nickel No. 2 0.001

LINEAR COEFFICIENT OF EXPANSION
.9 to 2.8 x 10^{-6} per °C. (20°—700° C.)

MELTING POINT— NONE. Will not soften, warp, fuse or flow.
Carbon sublimes without melting at 3500° C.

SPEER CARBON CO.
ST. MARYS, PA.
NEW YORK CHICAGO MILWAUKEE DETROIT PITTSBURGH CLEVELAND

417

III: That a minimum separation of 200 kc between adjacent f-m channels is, in our judgment, essential in order to accommodate facsimile by multiplex transmission and because of the fact that narrow band transmission may be carried on within such channels.

IV: That more than 5 adjacent channels for frequency modulation are essential.

V: The 41 to 44 Mc band should be allocated to stations using f-m transmission. Facsimile broadcasting should use f-m and these frequencies should be coordinated with sound broadcasting. Due consideration should be given to educational and facsimile transmission.

VI: It is recommended that the 26 megacycle band, now assigned to fm be allocated to other services.

VII: That in our judgment 15 megacycle band, now assigned to fm, the needs of fm and immediate provision should be made which will insure the availability of additional channels in the near future and that from the point of view of the receiver design, the additional channels should be as nearly adjacent to the band 41 to 44 megacycles as possible, insofar as this can be accomplished without undue injury to other services.

VIII: We recommend to the Commission separation distances for stations on the same channels and on adjacent channels for varying power

IX: That we request the Commission to set an established policy of permitting re-broadcasts between stations, subject only to permission of originating stations as is the rule in the regular broadcast band.

X: That we request the Commission to set an established policy of permitting relay stations on fm.

XI: Provision be made in the f-m band so as not to exclude educational and facsimile transmission from the band, the latter either on multiplex or simplex transmission.

Following Mr. Shepard, Dr. G. W. Pickard, consulting engineer for the Yankee Network, testified as a witness for F-M Broadcasters, Inc. Dr. Pickard recounted a series of field tests made to determine the signal strengths and noise in the areas surrounding the Paxton and Alpine f-m stations. The results of this survey were given in evidence. In general they proved the contentions pre-

Sure there are WESTONS for those *special* measurement needs!

HERE are just five of them. WESTON makes many more. Each designed to meet some particular measurement problem . . . make test procedure simple . . . less time-consuming . . . more efficient. Remember this whenever you are faced with some new or unusual measurement problem. Better yet . . . investigate these WESTON instruments *now* . . . for chances are that one or more will exactly meet your *present* needs. Consult the WESTON representative in your vicinity, or write Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, N. J.

AC Clamp-Ammeter—a real time saver. Simply hook the jaws around the conductor while machinery is running, and take the current reading. No production interruptions as circuits are never disturbed. Rugged construction, with high insulation. Six current ranges answer all maintenance needs.

Ultra High Frequency Oscillator—for checking and testing all types of communication equipment and carrier current systems operating in the high frequency bands. Has fundamental frequency coverage from 22 to 150 megacycles. Tests can be made with or without direct wire connection. Employs continuously variable inductive tuning, which provides high order of stability and resetability over entire range. Extremely portable, measuring only 8" x 8" x 11"—self contained power supply.

TENTH ANNIVERSARY

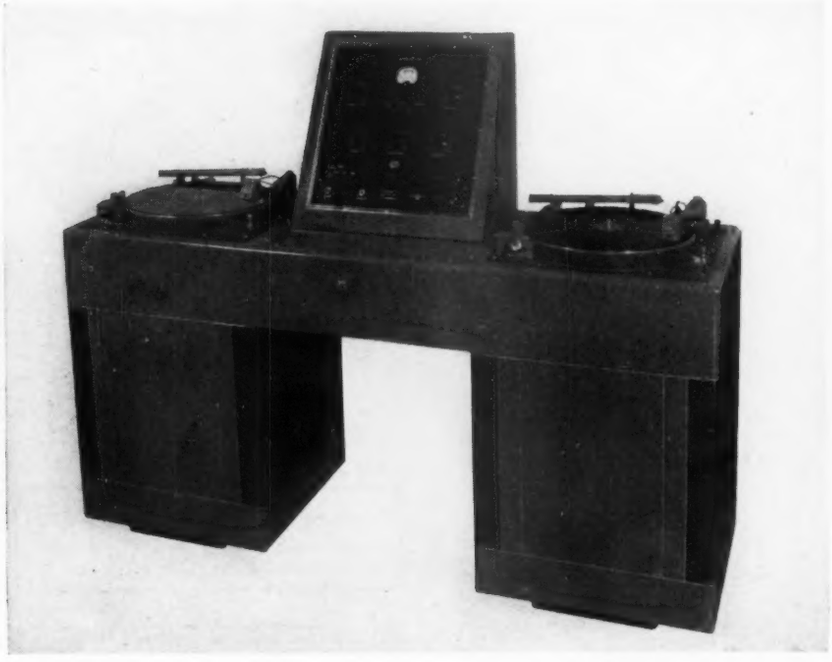
Hand-size AC Maintenance Voltmeter—has double range of 600 and 300 volts with push button switch for range selection—sensitivity 1000 ohms-per-volt. Case made of sturdy Bakelite with rotatable metal cover to protect instrument from rough handling. Has heavily insulated rubber covered leads and rubber sleeved test clips. Ideal for installation and maintenance testing of power and lighting circuits.

Industrial Circuit Tester—provides new convenience in testing signal, control and electronic circuits. Has 27 voltage, current and resistance ranges. High sensitivity for testing photo-cell, vacuum tube and relay circuits, and other plant maintenance and production requirements.

Pocket-size Dry Battery Tester—Measures "cut-off" voltages under proper load conditions. Ideal for checking dry batteries used in manufacturing or industrial control circuits. Ranges for testing batteries of following voltages . . . 1.5—4.5—6—7.5—45 and 90 volts.

WESTON *Instruments*

PRESTO offers a new
Dual Turntable Transcription Recorder
complete in a single unit



THIS new, moderately priced Presto Model F recorder makes the perfect installation for broadcasting stations, colleges, advertising agencies and personal recording studios. It records continuously, without interruption, on records up to the 17¼" master size and also re-records from one record to another. The quality of the recordings made on the model F recorder makes them suitable for use by any broadcasting station.

NOTE THESE OPERATING CONVENIENCES:

- The exclusive Presto rubber-rimmed turntable driven directly by a steel pulley on the motor shaft, a drive system that eliminates idler wheels, belts, gears and other parts subject to rapid wear. Speed shift-lever changes instantly from 78 to 33-1/3 R.P.M.
- Tables are equipped with the Presto 1-C high fidelity cutting head which records uniformly a range from 50 to 8000 cycles and completely modulates the groove at a pitch of 112 lines per inch.
- A vertical damper eliminates vertical modulation in the groove and prevents rapid changes in groove depth due to surface irregularities in the disc.
- A time scale on the cutting arm shows the correct starting point for all sizes of discs and elapsed recording time at both 78 to 33-1/3 R.P.M.
- Amplifier gain 125 DB, output 10 watts. Amplifier controls include a two microphone mixer, playback gain control, combination control which increases the high frequency response for 33-1/3 R.P.M. recording and attenuates the high frequencies when playing commercial records, low frequency equalizer and a switch for changing instantaneously between cutters for continuous recording or rerecording.
- The complete equipment mounts in a wood table (Length, 67"—Depth, 21"—Height, 49") attractively finished in two tones of gray with silver trim. Height of turntable above floor level, 32".

For descriptive folder and price quotations, write:

PRESTO RECORDING CORPORATION
242 West 55th St. New York, N. Y.

viously made, i.e. that noise is greatly reduced, that extremely minute signal strengths suffice to give satisfactory service (Dr. Pickard mentioned the figure of 10 microvolts being entirely satisfactory in quiet locations if the receiver sensitivity were high enough to cause proper limiter action at such an input voltage), and that the service range under these conditions was considerably better than that of standard amplitude modulation stations of equivalent power.

Messrs. Martino of WTIC and Noble of the University of Connecticut, followed with testimony concerning the f-m receivers installed in their respective homes, reporting high quality and freedom from noise compared with a-m transmissions from more powerful and less distant stations. Messrs. Gellerup of WTMJ and Sise of the Yankee network offered complete reports showing continuous field strength measurements in territory surrounding their respective f-m transmitters, which were accepted in the record by the Commission. Mr. Gellerup's report showed a curve (average over 9 radial measurements) of field strength vs distance for a 1000-watt f-m transmitter with half-wave vertical dipole 357 feet above ground. The field strengths varied from 500 microvolts per meter at 10 miles to 10 microvolts per meter at 39 miles. The field intensity contours were roughly circular about the transmitter location at Milwaukee.

The final witness during the first week of testimony was Maurice Levy of Stromberg-Carlson, also testifying for F-M Broadcasters, Inc. He described the construction of three f-m receivers in the Stromberg-Carlson laboratories, to test the relative advantages of frequency swings at 30, 60, 120 and 150 kc. The results showed little if any difference in frequency response or harmonic distortion, but very considerable differences in signal-to-noise ratio and in the ease of tuning the receivers. The report favored the 150 kc swing as being the most desirable, stating that with a wide-open audio system only the wide swing would give sufficient freedom from noise to avoid objectionable tube hiss, etc. The need for drift-free oscillators was emphasized as an important problem if easy tuning was to be offered the public.

THE 6th TENTH CHARTER ADVERTISER ANNIVERSARY of Ferranti Progress

• *60 Years of Development*

Rapid as has been the development of the Electronic Industry, FERRANTI PRODUCTS have kept pace with its demands . . . . until today this outstanding organization has rightfully taken its place as one of the chief factors in the progress made in this field.

Ferranti prestige is founded upon Ferranti Quality—a standard that has never been excelled.

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FOR VALUE RECEIVED

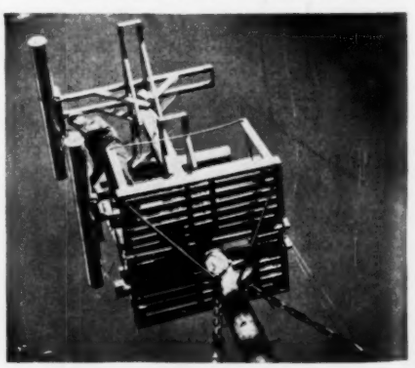
RCA Agrees FM Should Get "Green Light"

The highlight of the second week of the hearing was the testimony of witnesses for the Radio Corporation of America and its subsidiaries. Cross-examination of the earlier witnesses by the RCA counsel had led observers to expect stiff opposition on the part of RCA. Instead, Chief Counsel Wozencraft on March 27th announced that it was the opinion of his company that frequency modulation should be given the "green light", and that it be permitted to operate on a commercial basis as a supplement to the standard broadcast service. Mr. Wozencraft pointed out however that service to rural and small-town regions must always be provided by methods now used in standard broadcasting.

The question of the competition between frequency modulation and television for ether space then took the center of interest. Regarding the proposal that television channel number 1 (44–50 Mc) be turned over to frequency modulation, Mr. Wozencraft suggested that it should be one of the other channels, since that channel is now in regular use. If the channel were assigned to f-m uses, it was proposed that exceptions be made in the allocation for cities where the television channel is now in use. Regarding the desirable bandwidth, the RCA engineers granted that the wider the band the better the signal-to-noise ratio, but urged that the proper compromise between desired signal-to-noise performance and the number of available channels might be made equitably on a narrower band than that suggested by Major Armstrong.—D.G.F.

• • •

TELEVISION ANTENNA



Half-cubic antenna used for picture transmission at the General Electric television station erected on Helderberg Mountain in New York State

FM

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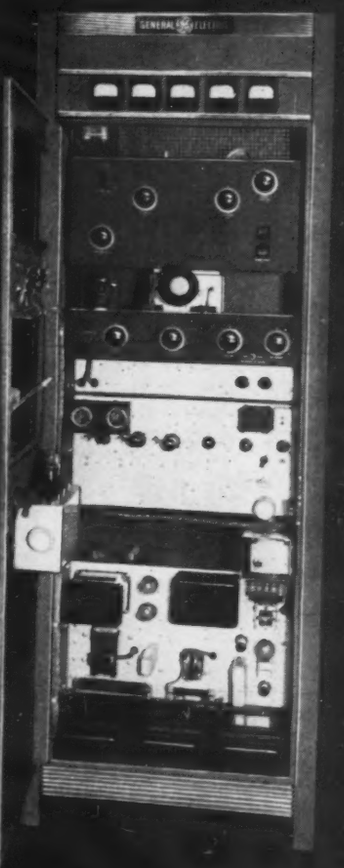

TRIM, NEAT, ACCESSIBLE — a glance tells you that. Our performance figures on this new G-E 250-watt F-M transmitter tell much more — tell, for example, that when you turn to F-M, you, your audience, your engineers, and your budget will all agree to go G-E.

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GENERAL ELECTRIC

TUBES

Methods for measuring r-f distortion in pentodes are presented together with the tube registry list for February 1940 and the last quarter of 1938

Simple Methods for Checking R-F Distortion or Cross-Modulation of Pentode Amplifier Tubes

By E. W. HEROLD
RCA Manufacturing Co., Inc.

IT HAS BEEN KNOWN for many years that the tubes used for radio frequency and intermediate-frequency amplification cause distortion of a modulated wave and cross-modulation between two modulated waves.[1] Although the theory is well understood, measured data on the performance of existing tubes in this respect have not often been published, at least in the United States. One reason for this is that the data are not so easy to obtain as the normal static characteristics of plate current, transconductance, etc. The purpose of the present note is to outline two simple methods used by the writer for determining modulation-envelope distortion and cross-modulation of screen-grid amplifier tubes. The only major equipment necessary is an accurate transconductance bridge with a sharply tuned balance indicator. Such equipment is usually available in most laboratories connected with the use or manufacture of tubes.

The methods to be described give an approximation to the exact result which is usually sufficiently close for practical purposes. It is easily shown that for small distortions, the distortion with a given signal is directly proportional to the incremental change in tube transconductance as the signal is changed from an infinitesimal value to the given signal value. Thus by measurement of the increment of transconductance when a large grid swing is present, a measure of the r-f distortion and cross-modulation is obtained. The approximate nature of the result is due to the neglect of the effect of derivatives, of higher order than the third, of plate current with respect to grid voltage. For small distortions the approximation is justified. Plate circuit distortion is not measured by the methods to be described, but this form of distortion is not usually of importance in screen-grid pentodes.

Theory

The plate current of a screen-grid tube may be expressed as a power series.

$$i_b = I_{bo} + g_{mo}\, e_g + \frac{1}{2!}\frac{\delta^2 i_b}{\delta e_c^2}\Big]_o e_g^2 + \frac{1}{3!}\frac{\delta^3 i_b}{\delta e_c^3}\Big]_o e_g^3$$

where the subscript o indicates values taken at the operating point, e_c is the grid voltage and e_g its alternating part. If a desired modulated wave of carrier amplitude E_1 and modulation ratio m_1, ie, a wave of value

$$E_1 (1 + m_1 \sin pt) \sin \omega_1 t,$$

is applied to the grid, it is readily shown that the output will be a modulated wave with a slightly different percentage of modulation and with second and third (and higher) harmonics of the p frequency present in the modulation envelope. Neglecting the higher order terms in the power series, because they are usually small, we find that, for the output,

Change in modulation ratio

$$= m_1 \left(\tfrac{1}{4} - \tfrac{3}{32}\, m_1^2\right) \frac{\delta^3 i_b/\delta e^3]_o}{g_{mo}}\, E_1^2 \qquad (1)$$

Ratio of 2nd harmonic in envelope to fundamental

$$= \tfrac{3}{16}\, m_1 \frac{\delta^3 i_b/\delta e_c^3]_o}{g_{mo}}\, E_1^2 \qquad (2)$$

Ratio of 3rd harmonic in envelope to fundamental

$$= \tfrac{1}{32}\, m_1^2 \frac{\delta^3 i_b/\delta e_c^3]_o}{g_{mo}}\, E_1^2 \qquad (3)$$

If an additional (and, presumably, an undesired) modulated carrier is impressed on the grid of the form

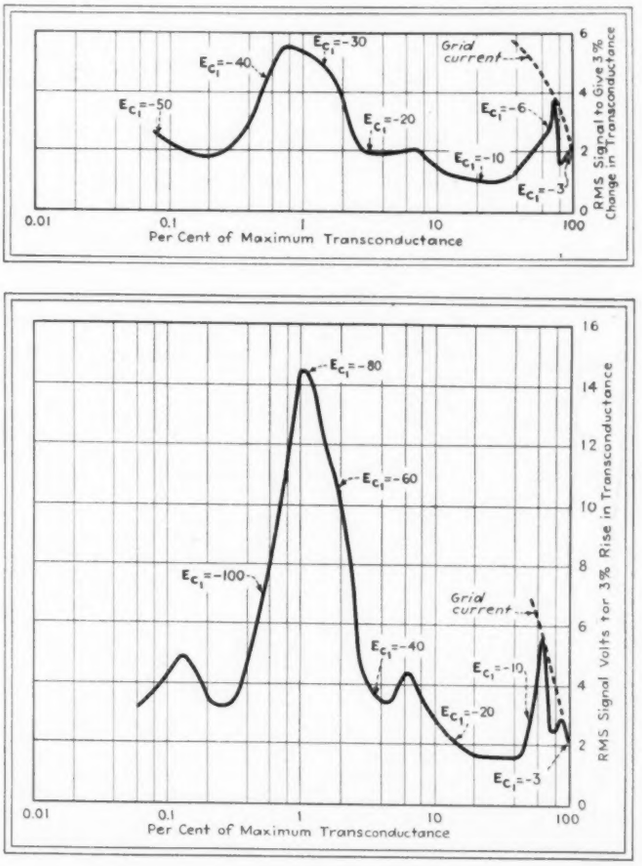
$$E_2 (1 + m_2 \sin qt) \sin \omega_2 t$$

it will be found that the first carrier, of angular frequency ω_1, will be modulated by the q frequency to a ratio

Cross-modulation ratio

$$= \tfrac{1}{2}\, m_2 \frac{\delta^3 i_b/\delta e_c^3]_o}{g_{mo}}\, E_2^2 \qquad (4)$$

These four factors are the important ones in the distortion analysis. All are seen to depend on the ratio of third to first derivative of plate current end on the square of the voltage. If an alternating grid voltage (approximately a sine wave) is applied to a tube, as in a transconductance bridge, it is easily



Distortion curves for tube type 6K7 by a method described here. In the top curve the screen voltage was constant at 100 v and in the lower curve the screen voltage was 250 v applied through 90000 ohms. The other electrode voltages were: $E_f = 6.3$; $E_p = 250$; $E_{c3} = 0$

ISOLANTITE INSULATORS

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Among the parts which prove they can take more punishment than ever would be anticipated in actual use are Isolantite* Insulators. For Isolantite possesses great structural strength which assures mechanical protection against the shocks and stresses of actual use, and permits small, compact insulator design with thin, weight- and space-saving cross-sections.

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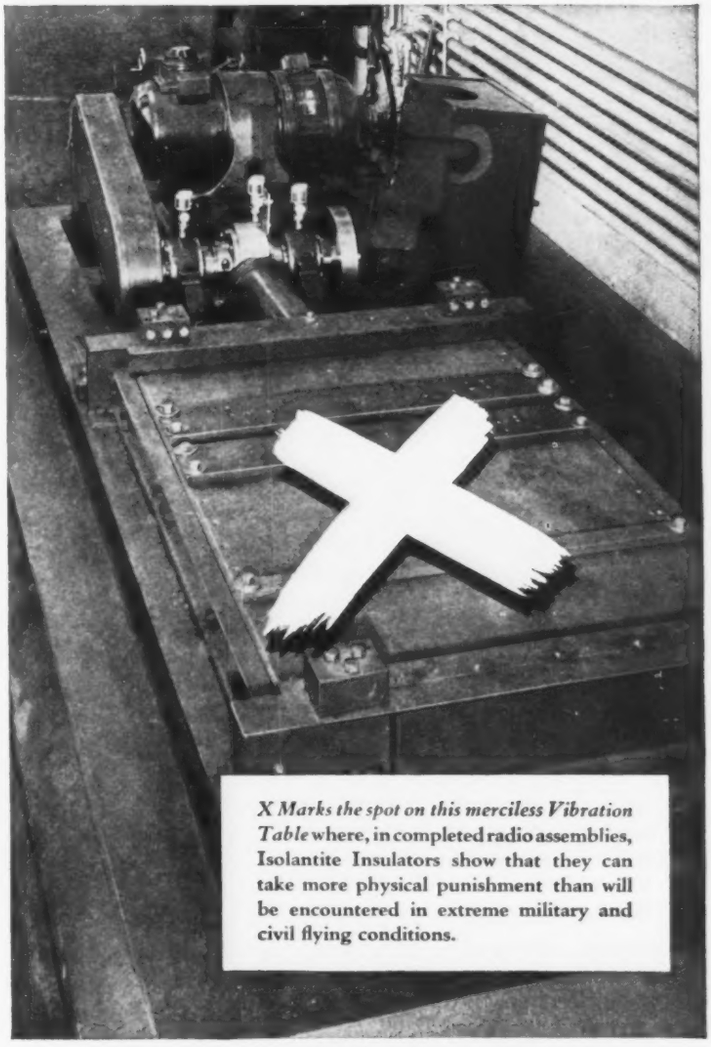

X Marks the spot on this merciless Vibration Table where, in completed radio assemblies, Isolantite Insulators show that they can take more physical punishment than will be encountered in extreme military and civil flying conditions.

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THE NEXT TEN YEARS

Certainly the past ten years have been remarkable and far-reaching advances in electronics and in radio engineering. And Isolantite is proud to have been associated with this progress; glad to have been a contributor to the development of better, more efficient insulating equipment and materials during the past decade. We are confident, too, that the next ten years will see still further increases in the value of our services and products to these branches of the electrical industry.

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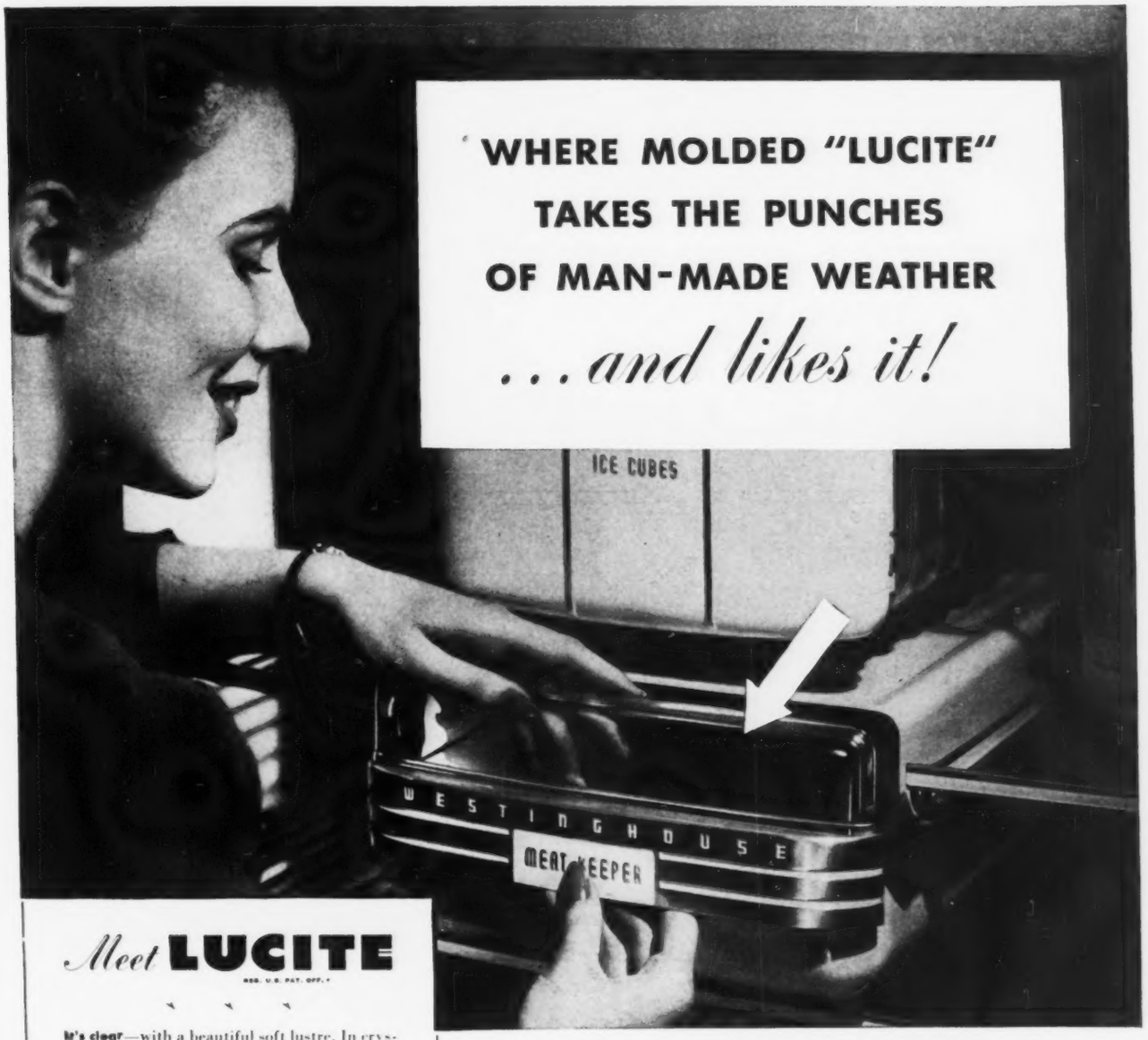

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It has high dielectric strength—
Dielectric constant: 60 cycles, 3.5 to 4.5
10^6 cycles, 2.5 to 3.0
Power factor: 60 cycles, 0.06 to 0.08
10^6 cycles, 0.01 to 0.03

It's easily molded—from highway reflectors to wet cell batteries, it's helped solve scores of difficult jobs.

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See where you can use such a material. One that sparkles in its crystal visibility. Stands up to strain or rough usage. Resists moisture, chemical action and temperature changes.

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PLASTICS

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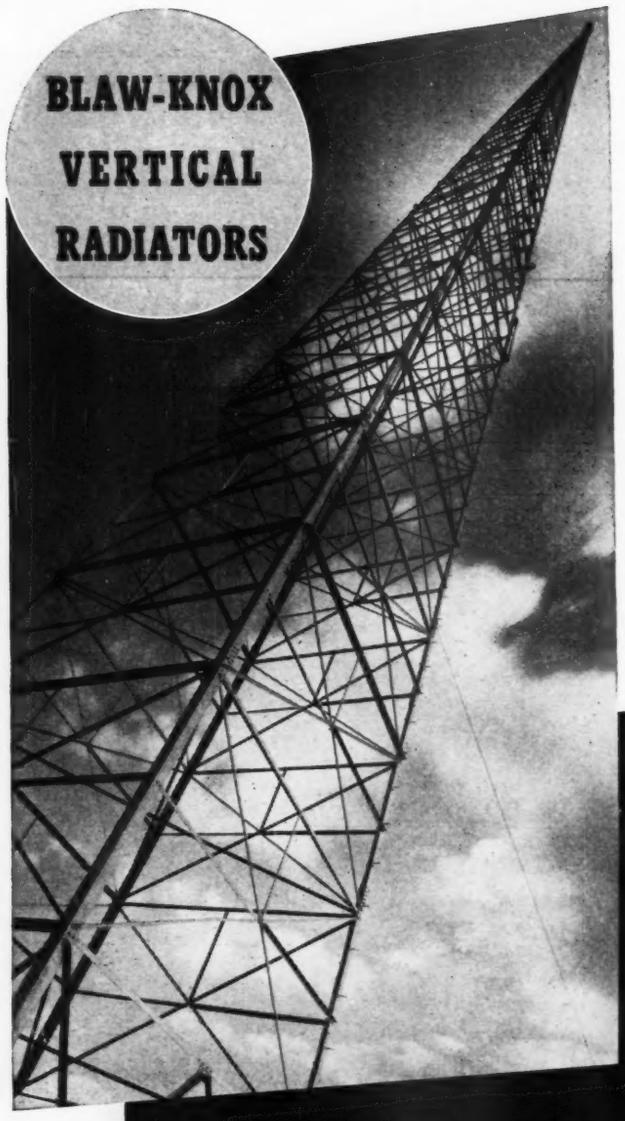

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shown that the ratio of fundamental-frequency output current to fundamental-frequency grid voltage is

$$g_{meff} = g_{mo} + \tfrac{1}{8}\left[\frac{\delta^3 i_b}{\delta e_c^3}\right]_o E_o^2$$

where E_o is the peak grid alternating voltage. When E_o is small, this expression reduces to g_{mo} which is commonly defined as the transconductance. For larger values of E_o the expression may be written

$$g_{meff} = g_{mo}\left(1 + \frac{\Delta g_m}{g_{mo}}\right).$$

Thus the ratio

$$\frac{\Delta g_m}{g_{mo}} = \tfrac{1}{8}\frac{[\delta^3 i_b/\delta e_c^3]_o}{g_{mo}} E_o^2 \qquad (5)$$

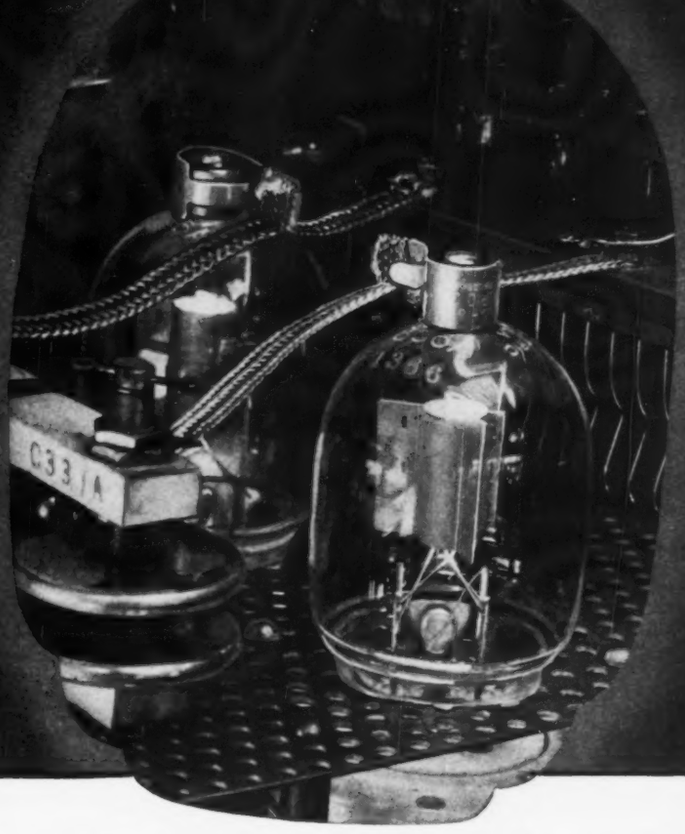
may be used to evaluate the distortion factors. Thus, if a tube is connected in a transconductance bridge, a transconductance reading taken with a small signal and the reading called g_{mo}, another reading taken with a given larger signal and the second reading called g_{meff}, all the necessary data are at hand for the determination of the distortion, provided the larger signal swing, E_{o2} is known. Letting $(g_{meff} - g_{mo}) = \Delta g_m$, Equations (1) to (5) give the following results:

• • •

RECORDING DEVICE DEVELOPED

Harrison Gipe, engineer in a pretzel factory in Reading, Pa. with his "Magnaphone", a steel tape recorder whose development has been recently announced. Using wire nine-thousandths of an inch thick, the device can now make recordings one hour and fifteen minutes long, but could be designed to make recordings five or six hours in length

356A gets another job!



Western Electric "Ultra-High" Amplifier Tube proves ability in frequency modulated transmitters

A pair of 356A's in a push-pull oscillator will put out 150 watts at 100 megacycles or 100 watts at 150 megacycles. The tube is so short, with lead-ins of such low inductance, that a pair can be neutralized perfectly for these frequencies. The 356A can be used to advantage in frequency modulated transmitters.

All solid dielectrics are eliminated inside the envelope since the electrodes are supported directly by heavy leads. A center tap for the filament is brought out to one base stud.

The base is a standard 50 watt ceramic wafer which fits standard 50 watt sockets without shells or specially designed Western Electric 152A type socket.

A pigmy in size but a glutton for punishment, the 356A utilizes Western Electric stemless type construction permitting the shortest grid filament and plate leads. Note that the plate terminal is welded too.

Get full details from distributors listed below.

Western Electric

CHARACTERISTICS

Filament voltage	5 volts	Maximum plate dissipation	50 watts
Filament current	5 amperes	Amplification factor	50
Maximum DC plate voltage	1500 volts	Overall height	4½ inches
Maximum DC plate current	120 milliamperes		

Maximum ratings apply up to 100 megacycles

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TENTH ANNIVERSARY

They might be called the "turbulent thirties" but there were some bright spots in the decade just passed that you cannot overlook. Take for instance the achievements of G-E Textolite and *Electronics* magazine.

Pages of this issue speak for themselves in paying tribute to McGraw-Hill's outstanding publication. So let's take a look at the record of General Electric's plastics activity in the electronics field.

Since the day ten years ago when *Electronics* first appeared, General Electric—with the help and co-operation of the industry's engineers—has developed many new applications. Standard insulating materials have been improved in quality and costs have been reduced.

Use of Textolite laminated plastics has brought about a reduction in electrical losses and, by reducing moisture absorption, has meant an improvement in circuit stability. At the same time, machinability and punchability of this material has constantly grown better.

For the radio industry, new developments in this period include speaker cones, diaphragms and dust caps. But better materials and lower costs have helped the newer electronic applications as well.

Use of Textolite molded plastics has resulted in better designed cabinets, bezels and knobs to enhance the external appearance of radios.

All this has been accomplished in the "turbulent thirties." And yet, looking ahead at the plastics development under way in General Electric's laboratories, there can be no doubt that improvement in materials and reduction in costs will proceed at an accelerated pace in the next decade to come.

PLASTICS DEPARTMENT

GENERAL ELECTRIC

PD-403

$$\% \text{ change in modulation} = 2\,(1 - \tfrac{3}{8}\,m_1^2)\,\frac{\Delta g_m}{g_{mo}} \times 100 \qquad (6)$$

$$\% \text{ 2nd harmonic distortion} = \frac{3}{2}\,m_1\,\frac{\Delta g_m}{g_{mo}} \times 100 \qquad (7)$$

$$\% \text{ 3rd harmonic distortion} = \tfrac{1}{4}\,m_1^2\,\frac{\Delta g_m}{g_{mo}} \times 100 \qquad (8)$$

$$\% \text{ cross-modulation by undesired carrier} = 4\,m_2\,\frac{\Delta g_m}{g_{mo}} \times 100 \qquad (9)$$

where, of course, m_1 is the fractional modulation of the desired carrier and m_2 is the fractional modulation of the undesired carrier.

A second and slightly different method, which may also be used, does not require that the a-c signal supplied by the bridge to the grid of the tube under test be increased. Instead, the signal remains small but a second larger alternating voltage of another frequency is superimposed. The second voltage should be of a much higher frequency than that of the signal used in the bridge (so high that the balance indicator does not pass it or its harmonics). If the second and larger signal has an amplitude E_o, the transconductance reading will be the average over a cycle of the larger signal and is found to be

$$g_{m\,av\,g} = g_{mo}\left(1 + \tfrac{1}{4}\,\frac{\delta^2 i_b/\delta e_c^2]_o}{g_{mo}}\,E_o^2\right) = g_{mo}\left(1 + \frac{\Delta g'_m}{g_{mo}}\right) \qquad (10)$$

where $\Delta g'_m$ is the increment found by the second method.

By reading the transconductance with the extraneous signal removed, (i.e., $E_o = 0$) the value g_{mo} is found and again the distortions may be calculated provided E_o is measured. The relations are similar to those of Equations (6) to (9) except that it must be remembered that $\Delta g'_m = 2\,\Delta g_m$.

Practical Application

The two methods outlined may be applied to any transconductance bridge with a sharply tuned balance indicator and capable of accurate balance, preferably to less than one-half per cent. For the first method, the a-c supply to the bridge must be variable and, at its maximum value, must supply a grid voltage of several volts to the grid of the tube under test. In the second method, an additional signal whose fundamental frequency and harmonics do not operate the balance indicator must be applied to the grid in series with the a-c voltage supplied by the bridge. The latter should be as small as usual for transconductance measurements (e.g., of the order of 0.1 volt or less) whereas the additional signal must be larger. With both methods the alternating grid voltage must be measured.

In most cases, the most desirable

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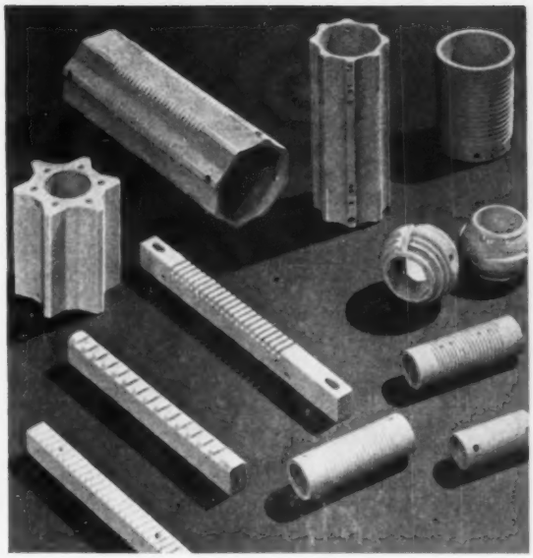

Ten years ago, when the bands above 56 megacycles were mostly silent, nearly any r.f. insulation was good enough. Today, with the extended r.f. spectrum already probing into new unknowns, the lower loss-factors of General Ceramics Ultra-Steatite insulators are *essential* to the solution of many new problems in both radio and television.

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If you have not received your copy of this new catalog, send for it now, while you have it in mind. It lists hundreds of items and contains much helpful data on insulation problems.

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data are the magnitude of the signals which will give rise to a given amount of distortion or cross-modulation. Such data are obtained directly by the above methods with the following procedure.

Method 1. Using a small grid signal on the tube under test, the transconductance bridge is balanced. When the distortion or cross-modulation figure is chosen, Equations (6) to (9) give $\frac{\Delta g_m}{g_m}$, the percentage change in transconductance necessary. For example, suppose 5 per cent second harmonic is chosen for $m_1 = 1$. Equation (7) gives $\frac{\Delta g_m}{g_m} =$ 3⅛ per cent. The transconductance bridge is then unbalanced by 3⅛ per cent and the a-c supply to the bridge is increased slowly until a balance is again attained or grid current is reached. The alternating grid voltage is then the desired answer. If grid current is reached before the new balance is obtained, however, it will be necessary to reverse the direction of the 3⅛ per cent initial unbalance and repeat the procedure. The smallest of the two alternating grid voltages measures the signal-handling ability of the tube.

Method 2. With the additional higher frequency a-c signal turned off, the transconductance bridge is balanced. The bridge is then unbalanced by the chosen amount as in Method 1. The additional signal is then gradually increased until the bridge balances or grid current is reached. The magnitude of the grid signal is then recorded. If grid current is reached, the initial unbalance should be reversed in direction and the procedure repeated.

It is, of course, necessary with both methods that the voltages be well regulated during the measurement to prevent the electrode voltages from varying with tube current. In taking data for series-screen resistor operation, it is necessary to substitute a steady screen voltage while the actual data are taken. This is done by using the series resistor for the initial small-signal balance, and substituting a fixed voltage which will give the same balance.

As an illustration, data were obtained on the type 6K7 pentode using Method (1) and are shown in the accompanying diagrams. The data show the amount of signal at any given grid bias value which will give a 3 per cent change in effective transconductance, or a second harmonic distortion of a modulation envelope of 4½ per cent, a third harmonic distortion of ¾ per cent, or the amount of undesired signal which will, when 100 per cent modulated, give a cross-modulation of 12 per cent. The data are plotted on semi-log paper using the percentage of maximum transconductance as the abscissa scale. This method of plotting is valuable in comparing tubes.

[1] Ballantine and Snow, Reduction of Distortion and Cross-Talk in Radio Receivers by Means of Variable-Mu Tetrodes; *Proc. I.R.E.*, Vol. 18, pp. 2102–2127, Dec. 1930.

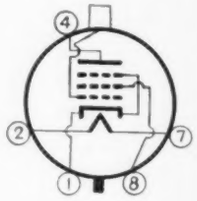
Tube Registry

NOTICE: The sponsor of tube type 6S6GT has modified the basing of this tube type from that shown on page 62, March, 1940 issue of *Electronics*. As there indicated the basing is described by designation 6AV. As modified the basing is described as 5AK.

Type 6S6 (GT)

R-F pentode, remote cutoff; heater type; (T-9) glass envelope; seated height 3¼ inches (max); 5 pin octal base.

E_h = 6.3 v
I_h = 0.45 amp
E_p = 250 v
E_{c2} = 100 v
E_{c1} = − 2 v
I_p = 13 ma
I_{c2} = 3 ma
g_m = 4000 μmhos
r_p = 0.35 megohm
C_{in} = 7 μμf
C_{out} = 6.4 μμf
C_{gp} = 0.01 μμf
Basing 5AK



Tube Types Registered by R.M.A. Data Bureau During February 1940

Type 12J7 (G)

Prototype 6J7 (G)

R-f pentode; sharp cutoff; heater type; (ST-12) glass envelope; seated height, 3 29/32 inches (max); 7 pin octal base.

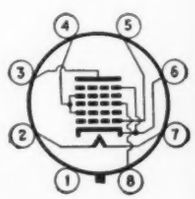
E_h = 12.6 v
I_h = 0.15 amp
E_p = 250 v
E_{c2} = 100 v
E_c = − 3 v
I_p = 2.0 ma
I_{c2} = 0.5 ma
r_p = 2 megohms (approx)
g_m = 1225 μmhos
C_{g1p} = 0.007 μμf (max)
C_{in} = 4.6 μμf
C_{out} = 12 μμf
Basing 7-R

Type 12SA7 (G)

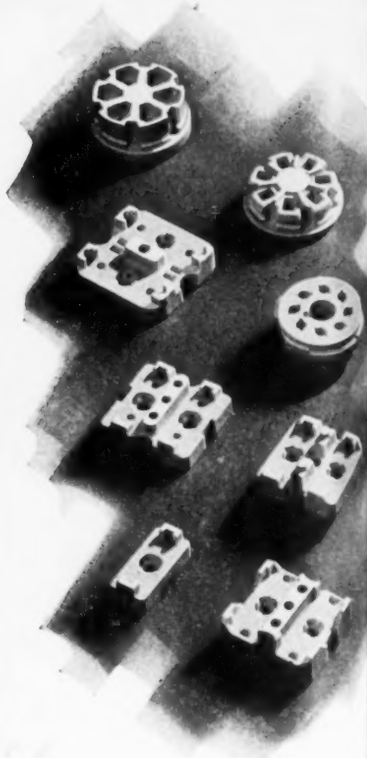
Prototype 12SA7 (GT)

PENTAGRID converter; heater type; (T-9) glass envelope; seated height 3 9/16 inches (max); 8 pin octal base.

E_h = 12.6 v
I_h = 0.15 amp
E_p = 250 v
E_{c2} = 100 v
E_{c5} = E_{c3} = 0 v
I_p = 3.5 ma
I_{c2} + $2,4_1$ = 8.5 ma
g_c = 380 μmhos
r_p = 1 megohm (approx)
E_p = E_{c2} $2,4_1$ = 100 v
E_{c5} = E_{c3} = E_{c1} = 0 v
I_p = 27 ma
μ = 13
g_m = (between g_1 and $(p + g_2 + g_5)$ = 4500 μmhos
$C_{rf\,in}$ = 10.5 μμf
$C_{if\,out}$ = 12 μμf
Basing 8-AD



HERE'S
made foo



A SPECIAL PROBLEM?

Let our technical staff assist you. General Ceramics facilities for developing and fabricating special products to exacting specifications are unsurpassed.

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And whether your needs are special or routine, we offer you SERVICE . . . prompt attention to your inquiries and orders . . . the advantages of up-to-date production facilities . . . and QUICK DELIVERIES.

GENERAL CERAMICS COMPANY
INSULATORS

YOU ARE READING . . .

The biggest issue of ELECTRONICS ever published — biggest in circulation, editorial and advertising content of any of the 121 issues brought out since volume 1, number 1, April, 1930.

Represented in the advertising columns are a majority of the existing charter advertisers, and a who's who of the important companies in the electronic and allied fields.

ELECTRONICS
IS PROUD OF THE COMPANIES IT KEEPS

ELECTRONICS • *A McGraw-Hill Publication* • 330 W. 42nd St., New York, N.Y.

NEW ICONIC CONSOLE

Beautifully-balanced tone quality and even response throughout a long tone range are obtained in the Iconic System by the same method used in Lansing's finest theatre systems—a two-way system using a dividing network and separate speakers for the reproduction of high and low frequencies. The result is clear brilliant high tones and deep resounding lows with every subtle overtone and undertone faithfully reproduced.

The Iconic System is now offered in a beautiful new modern console cabinet. It is solidly constructed, and the polished finish has an underlying lustre of opalescent silver. It has been thoroughly tested for acoustical correctness. The Iconic System is ideal for small theatres, public address work, school auditoriums, churches, monitor and audition rooms, sound studios, and fine residential installations.

Model 816

It is available with either electrodynamic or permanent magnet speakers. Models are made with various special amplifiers, also. Production has just been stepped up on the Iconics and the whole line lowered in price. Complete literature can be had upon request. It will pay you to investigate the Iconic Systems.

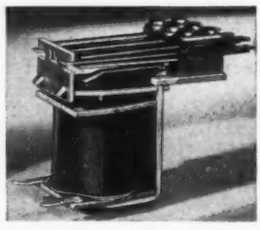
LANSING MANUFACTURING COMPANY

6900 McKinley Avenue — Los Angeles, California, U.S.A.

NEW TYPE RELAY NOW AVAILABLE

A Sturdy and Sensitive Design at Low Cost

This new relay, just perfected, costs less because it has fewer parts. Its brand new design affords greater sensitivity, too. So you can save money and get a better relay by switching to this new model. Investigate today.



Details and prices on a wide range of contact combinations given in illustrated circular just released. Write for copy to American Automatic Electric Sales Company, 1033 W. Van Buren Street, Chicago.

AUTOMATIC ELECTRIC

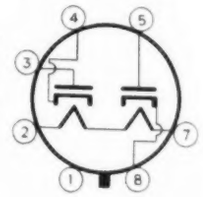
MAKERS OF TELEPHONE AND SIGNALING APPARATUS
ELECTRICAL ENGINEERS, DESIGNERS, & CONSULTANTS

Type 50Y6 (G)

Prototype 50Y6 (GT)

RECTIFIER-DOUBLER; heater type; (ST-12) glass envelope; seated height, 3 9/16 inches (max); 7-pin octal base.

E_h = 50 v
I_h = 0.15 amp
As Half-Wave Rectifier
E_{ac} = 235 v (max)
I_{dc} = 75 ma per plate (max)
E_{drop} = 22 v @ 150 ma per plate
Basing 7-Q

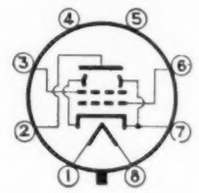


Tube Types Registered by R.M.A. Data Bureau During the Last Quarter of 1938

Type 6R6 (G)

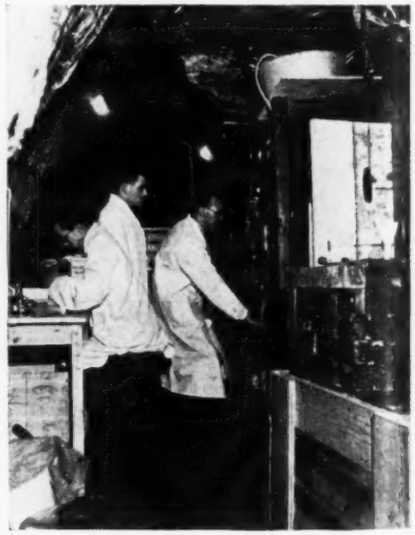
R-f pentode, remote cutoff, heater type, glass envelope, 8 pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v
E_{c2} = 100 v
E_c = −3.0 v
I_p = 7.0 ma
I_{c2} = 1.7 ma
r_p = 0.8 megohm
g_m = 1450 μmhos
Basing 6-AA



• • •

RADIUM EXPERTS WORK IN CAVES

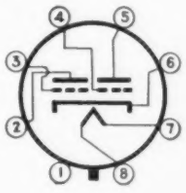


In the Derbyshire caverns in England, 280 feet below the ground, a group of workers are engaged in extracting radon gas from radium as a war safety measure. Radon gas is said to have almost the same properties as radium and has the added advantage, for war times, of losing its effectiveness within a few days

Type 6SC7

TWIN triode amplifier, heater type, metal envelope, 8 pin octal base.

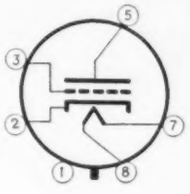
E_h = 6.3 v
I_h = 0.3 amp
(Each triode)
E_p = 250 v (max)
E_c = − 2.0 v
I_p = 2.0 ma
r_p = 53000 ohms
g_m = 1325 μmhos
μ = 70
Basing 8-S



Type 6SF5

SINGLE ended high mu triode, heater type, metal envelope, 6 pin octal base.

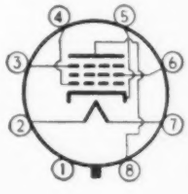
E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v (max)
E_c = −2.0 v
I_p = 0.9 ma
r_p = 66000 ohms
μ = 100
Basing 8-P



Type 6SJ7

SINGLE ended r-f pentode, sharp cutoff, heater type, metal envelope, 8 pin octal base.

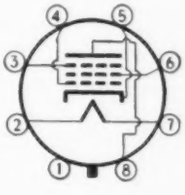
E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v (max)
E_{c2} = 100 v
E_c = −3.0 v
I_p = 3.0 ma
I_{c2} = 0.8 ma
r_p = 1.5 megohms
g_m = 1650 μmhos
Basing 8-N



Type 6SK7

SINGLE ended r-f pentode, remote cutoff, heater type, metal envelope, 8 pin octal base.

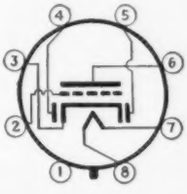
E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v (max)
E_{c2} = 100 v
E_c = −3.0 v
I_p = 9.2 ma
I_{c2} = 2.4 ma
r_p = 0.8 megohm
g_m = 2000 μmhos
Basing 8-N



Type 6SQ7

SINGLE ended double diode high mu triode, heater type, metal envelope, 8 pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v
E_c = −2.0 v
I_p = 0.9 ma
g_m = 1100 μmhos
μ = 100
Basing 8-Q



DIRECT READING FREQUENCY MONITOR

MODEL FD8 BY *Doolittle*

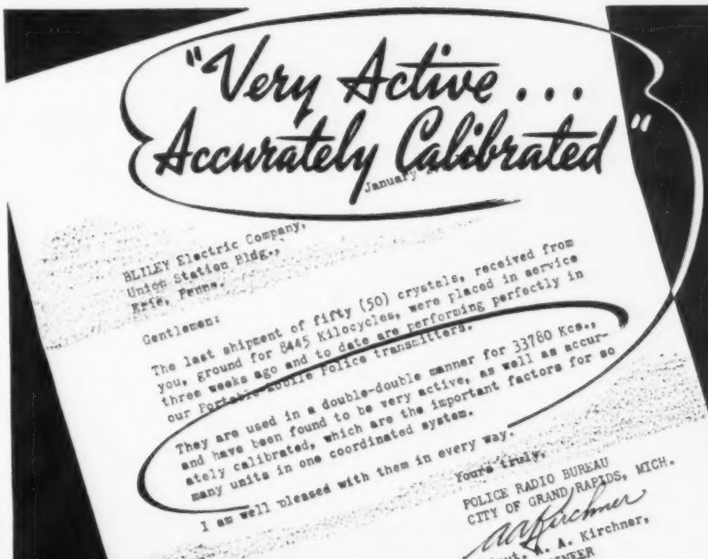
FEATURES:

- Provides *direct* reading of frequency deviation.
- Temperature controlled crystal chamber.
- Monitors four frequencies.
- Operates on any frequency—1500 to 50,000 KC
- Accuracy of the monitoring frequency is .002 per cent
- Three ranges of measurement—1000, 5000, and 10,000 cycles

For further details write

DOOLITTLE & FALKNOR, Inc. 7421 S. LOOMIS BLVD. CHICAGO, ILLINOIS

"Very Active . . . Accurately Calibrated"



BLILEY Electric Company,
Union Station Bldg.,
Erie, Penna.

Gentlemen:

The last shipment of fifty (50) crystals, received from you, ground for 8445 Kilocycles, were placed in service three weeks ago and to date are performing perfectly in our Portable-Mobile Police transmitters.

They are used in a double-double manner for 33760 Kcs., and have been found to be very active, as well as accurately calibrated, which are the important factors for so many units in one coordinated system.

I am well pleased with them in every way.

Yours truly,
POLICE RADIO BUREAU
CITY OF GRAND RAPIDS, MICH.
Lieut. A. A. Kirchner,
CHIEF ENGINEER

BLILEY
CRYSTAL UNITS
FROM 20KC. TO 30MC.
WRITE FOR CATALOG G-11 DESCRIBING COMPLETE LINE
BLILEY ELECTRIC CO., ERIE, PA.

One Engineer Tells Another...

"Unattenuation field of station is equivalent to 270 mvm for a power of 1000 watts . . ."

Here is more evidence of the excellent efficiency of Lingo Vertical Tubular Steel Radiators. Such statements, and others from letters in our files, testify to the fact that Lingo Radiators are not only living up to claims, but are creating new ones! More and more alert engineers are becoming aware of the unusual results made possible by Lingo's fine quality design and construction.

Lingo "Tube" Radiators are constructed of new full-weight copper-bearing seamless steel tubing, which provides a considerably higher tensile strength than is found in other types. Combined with this assurance of stability, goes 43 years of experience and single responsibility in *constructing and erecting* our own radiators. There are many other features of interest. . . .

May we send you a complete technical report?

Simply send us the location, power and frequency of your station. We will send you full details without obligation.

JOHN E. LINGO & SON, INC.

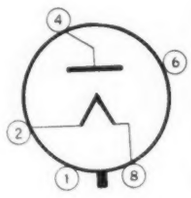
Dept. E-4, CAMDEN, N. J.

LINGO
VERTICAL TUBULAR STEEL RADIATORS

Type 2W3

HALF-WAVE high vacuum rectifier, filament type, metal envelope, 5 pin octal base.

E_f = 2.5 v
I_f = 1.5 amps
E_{ac} = 350 v (max)
I_{dc} = 55 ma (max)
Basing 4-X



Type 6P8 (G)

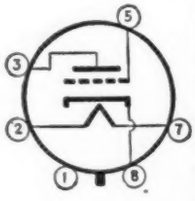
TRIODE-HEXODE converter, heater type, glass envelope, 8 pin octal base.

E_h = 6.3 v
I_h = 0.8 amp
$E_{p\ hexode}$ = 250 v (max)
$E_{c2,4\ hex}$ = 75 v
E_c = − 2.0 v
$E_{p\ triode}$ = 100 v
$R_{grid\ triode}$ = 50000 ohms
g_c = 650 μmhos
$I_{p\ hex}$ = 1.5 ma
$I_{c2,4\ hex}$ = 1.4 ma
$I_{p\ triode}$ = 2.2 ma
Basing 8-K

Type 25AC5 (G)

POWER amplifier triode, heater type, glass envelope, 6 pin octal base.

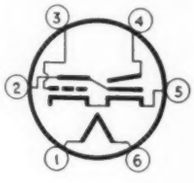
E_h = 25.0 v
I_h = 0.3 amp
E_p = 110 v
E_c = + 15 v
I_p = 45 ma
I_c = 7 ma
g_m = 3800 μmhos
R_l = 3500 ohms
P_o = 3.3 watts (10%)
Basing 6-Q



Type 6U5-6G5

TUNING indicator, heater type, (T9) glass envelope, 6 pin base.

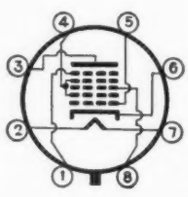
E_h = 6.3 v
I_h = 0.3 amp
Basing 6-R

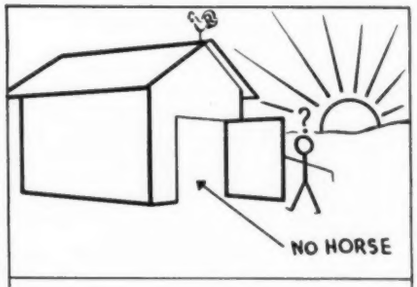


Type 6SA7

SINGLE ended pentagrid converter, heater type, metal envelope, 8 pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v
$E_{c2,4}$ = 100 v
E_{c3} = − 2 v
I_p = 3.4 ma
$I_{c2,4}$ = 8 ma
g_c = 450 μmhos
r_p = 0.9 megohm
Basing 8-R





" Locking the door after the horse is stolen" - -

IS FOLLY, but no more so than trying to save time and money winding your own resistors.

Our quality wire-wound resistors have helped many manufacturers boost the quality of their products and speed up production.

We take the resistance out of resistor problems.

Catalogue upon Request

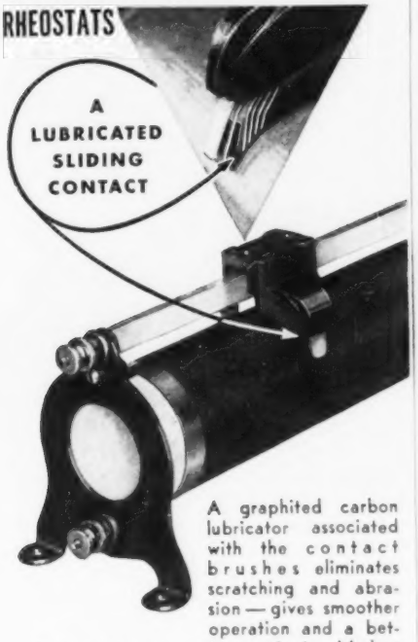
Instrument Resistors, Inc.
LITTLE FALLS, NEW JERSEY
MAKERS OF WIRE WOUND RESISTORS FOR THE ELECTRONIC INDUSTRY

SCRATCHY?

Remler Attenuators assure s-m-o-o-t-h mixing . . . completely eliminate "scratch." Silver blades on silver taps (.030" solid silver) machined to precision, "floated" on ball-bearings. Self-cleaning—soft thin silver oxide automatically wipes off with blade. Always quiet, even in low-level circuits. For complete specifications write:

REMLER COMPANY, Ltd.
19th at Bryant San Francisco

JAGABI *"Lubri-tact"* **RHEOSTATS**



A graphited carbon lubricator associated with the contact brushes eliminates scratching and abrasion — gives smoother operation and a better contact. Makes Jagabi Rheostats *better* rheostats.

Write for Bulletin 1620-E which lists new lower prices.

JAMES G. BIDDLE CO.
Electrical Instruments
1211-13 Arch Street Philadelphia, Pa.

ASTATIC CRYSTAL RECORDING HEAD

MODEL X-26

Designed for use in recording on acetate coated blanks. Also used on wax master plates. Especially suitable for home recording equipment. Heavy die-cast cartridge assembly develops remarkable power sensitivity capable of recording a range of frequencies far greater than formerly possible. Due to constant amplitude characteristic, higher volume levels can be recorded without groove crossover.

LIST PRICE NOW $11.50
(See Your Astatic Jobber)

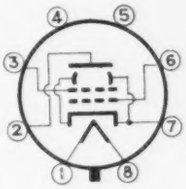
ASTATIC

Astatic Microphone Laboratory, Inc.
YOUNGSTOWN, OHIO
In Canada: Canadian Astatic Ltd., Toronto, Ontario
Astatic Crystal Products Licensed Under Brush Development Co. Patents

Type 35A5 (GL)

BEAM power amplifier, heater type, glass base-envelope, 8 pin loktal base.

E_h = 35.0 v
I_h = 0.16 ma
E_p = 110 v (max)
E_{c3} = 110 v (max)
E_{c1} = − 7.5 v (min)
I_p = 35 ma
I_{c1} = 2.8 ma
g_m = 5500 μmhos
R_{k1} = 2500 ohms
P_o = 1.4 watts
Basing 6-AA



Type 7A7 (GL)

R-f pentode, remote cutoff, heater type, glass base-envelope, 8 pin loktal base.

E_h = 7.0 v
I_h = 0.32 amp
E_p = 250 v (max)
E_{c2} = 100 v (max)
E_c = − 3.0 v
I_p = 8.6 ma
I_{c2} = 2.0 ma
r_p = 0.8 megohm
g_m = 2000 μmhos
μ = 1600
Basing 8-V

Type 7B7 (GL)

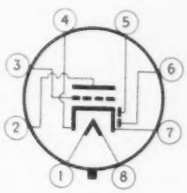
R-f pentode, remote cutoff, heater type, glass base-envelope, 8 pin loktal base.

E_h = 7.0 v
I_h = 0.16 amp
E_p = 250 v (max)
E_{c2} = 100 v (max)
E_c = − 3 v
I_p = 8.5 ma
I_{c2} = 0.7 ma
g_m = 1700 μmhos
r_p = 0.7 megohm
μ = 1200
Basing 8-V

Type 7C6 (GL)

DUODIODE triode, heater type, glass base-envelope, 8 pin loktal base.

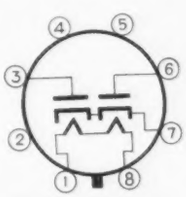
E_h = 7.0 v
I_h = 0.16 amp
E_p = 250 v (max)
R_{grid} = 10 megohms
I_p = 1.3 ma
r_p = 0.1 megohm
g_m = 1000 μmhos
μ = 100
Basing 8-W



Type 7Y4 (GL)

FULL-WAVE high vacuum rectifier, heater type, glass base-envelope, 8 pin loktal base.

E_f = 7.0 v
I_f = 0.53 amp
E_{ac} = 350 v per plate (max)
I_{dc} = 60 ma (max)
Basing 5-AB



PINCOR PRODUCTS FOR AIRCRAFT
AND OTHER SOUND OR POWER SUPPLY USES

HIGH FREQUENCY CONVERTERS

Pincor High Frequency Converters are precision built for smooth, silent, dependable performance. 5 to 500 watts. 400 and 500 cycles. Special units designed to meet any output or requirements.

SMALL MOTORS
A.C. and D.C.

These small motors are particularly adapted for band switching, remote control, etc., for aircraft use or wherever a small light weight motor is required for unfailing service. 20 watts output. Others as required.

DYNAMOTORS

Pincor Dynamotors afford a dependable "B" power supply for aircraft, marine and broadcast service, mobile units, etc. Highest efficiency and regulation. 5 to 850 watts. Input 6 to 110 volts; output up to 1750 volts.

PIONEER GEN-E-MOTOR CORP.
CHICAGO, ILLINOIS
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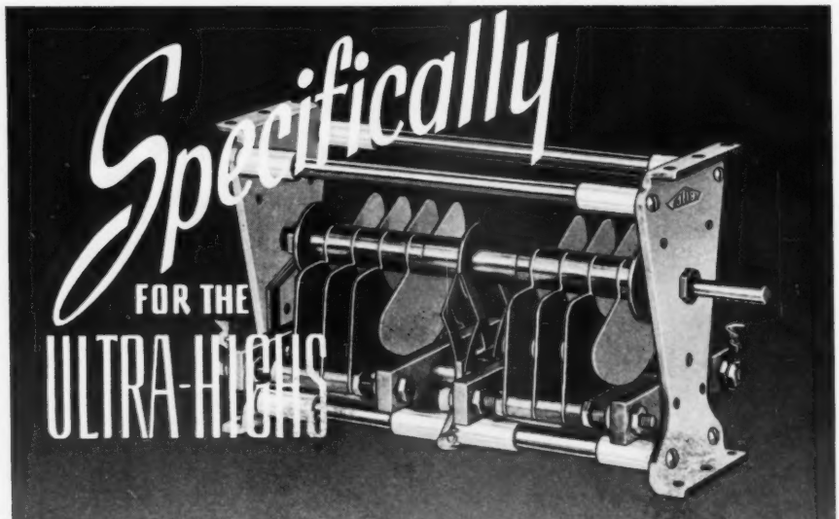
Cable: Simontrice, New York

PIONEER GEN-E-MOTOR CORPORATION
Dept. R-4 D, 466 W. Superior St., Chicago, Ill.
Please send information on the following:
☐ High Frequency Converters. ☐ Small Motors.
☐ Dynamotors. ☐ Rotary Converters.
Name .....
Address .....
City ..... State .....



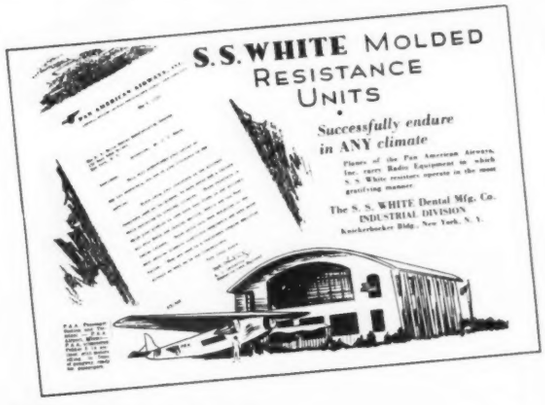
Designed to meet the particular requirements of Ultra-High Frequency Transmitting Equipment, the BUD lines of V. H. F. Transmitting Condensers assure peak tank circuit efficiency in such applications. Outstanding features include:

(1) Completely insulated tie rods—no closed metalic loop in condenser frame.
(2) Center-of-rod Rotor Contacts—permit perfect circuit balance.
(3) Highest grade low-loss ceramic used throughout.

Inquiries welcomed concerning your specific problems. Catalog Free on request.

BUD RADIO, INC. • Cleveland, Ohio

TENTH ANNIVERSARY



Now **they're known as**

the *"All-Weather"* resistors . . .

When this advertisement was run 10 years ago, the ability of S. S. WHITE Resistors to function efficiently under extremes of temperature, humidity and climatic changes, had already won wide recognition. This recognition was earned principally by the trouble-free performance of S. S. WHITE Resistors in radio equipment being used in planes flying in all parts of the world.

Today, the designation "All-Weather" resistors is fully and positively established and it accounts for the widespread use of S. S. WHITE Resistors in Commercial, Industrial and Scientific Equipment. S. S. WHITE Resistors are available in values from 1000 ohms to 1,000,000 megohms. Full details are given in RESISTOR BULLETIN 37. A copy, with Price List, mailed on request.

S. S. WHITE

The S. S. White Dental Mfg. Co.

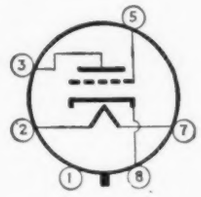
INDUSTRIAL DIVISION

Department R, 10 East 40th St., New York, N. Y.

Type 6AE5 (G)

TRIODE amplifier, heater type, glass envelope, 6 pin octal base.

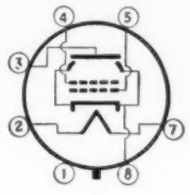
E_h = 6.3 v
I_h = 0.3 amp
E_p = 95 v
E_c = −15 v
I_p = 7 ma
r_p = 3500 ohms
g_m = 1200 μmhos
μ = 4.2
Basing 6-Q



Type 35L6 (GT)

BEAM power amplifier, heater type, bantam glass, 7 pin octal base.

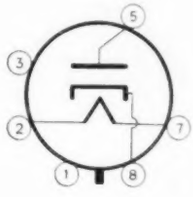
E_h = 35 v
I_h = 0.15 amp
E_p = 110 v (max)
E_{c2} = 110 v (max)
E_{c1} = − 7.5 v
I_p = 40 ma
I_{c2} = 3 ma
g_m = 5800 μmhos
μ = 80
R_l = 2500 ohms
P_o = 1.5 watts
Basing 7-AC



Type 35Z4 (GT)

HALF-WAVE high vacuum rectifier, heater type, bantam glass, 6 pin octal base.

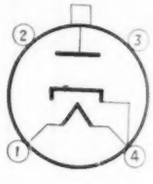
E_h = 35 v
I_h = 0.15 amp
E_{ac} = 125 v (max)
I_{dc} = 100 ma (max)
E_{drop} @ 200 ma = 16 v
Basing 5-AA



Type 2Y2

HALF-WAVE high vacuum rectifier, heater type, glass envelope, 4 pin base.

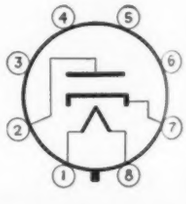
E_h = 2.5 v
I_h = 1.75 amps
E_{ac} = 4400 v (max)
I_{dc} = 5.0 ma
Basing 4-AB



Type 35Z3 (GL)

HALF-WAVE high vacuum rectifier, heater type, glass base-envelope 8 pin loktal base.

E_h = 35.0 v
I_h = 0.16 amp
E_{ac} = 250 v (max)
I_{dc} = 100 ma (max)
E_{drop} @ 200 ma = 22 v
Basing 4-Z



Electronic Organ

(*Continued from page 45*)

the insulation resistance must be high—at least a hundred megohms. Ordinary tape insulation is unsatisfactory and all leakage paths should have a full inch length.

Accessibility of all parts warrants careful consideration. Where separate channels are used for preamplifiers, the outputs can be arranged with detachable plugs.

Voicing of Pick-up Screws

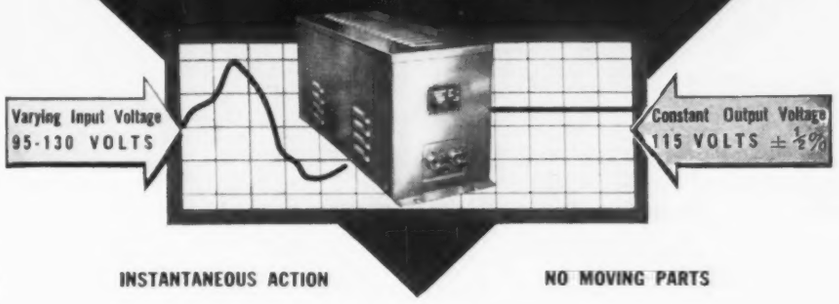
Having connected all the electric parts, one next proceeds to the voicing or adjustment of pick-up screws for uniform loudness from the loudspeaker. The first stage of this rough adjustment can take place by blowing a reed in normal manner while the screw is threaded in until a buzzing indicates contact is being made with vibrating tongue and then the screw is backed off a full turn.

The first precaution is to hold down adjoining bass keys and observe, when they are suddenly released, whether sharp clicks come from loudspeaker. If disagreeable noises do result, then the reed tongues are slapping against the screws so the latter must be backed off farther. When all such thumps have been eliminated by checking with various key combinations, then one can start to drop down the volume of the louder reeds to balance with the softer ones all over the keyboard. The extreme bass and treble may be a little weaker than the middle region but that is unimportant if there is no abrupt shift in volume going from one key to another. An a-c voltmeter across the voice coil furnishes the most convenient indication for volume equality, although the ear must be the final judge. Each rank of reeds is voiced separately before their outputs are combined.

Setting up the Stops

If there are already stop draw knobs on the console, these may be marked 16 feet, 8 feet, and 4 feet, and this designation refers to the frequency of each set of reeds. For

STABILIZED A. C. VOLTAGE
UP TO 25 KVA



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When a precision electrical device or a critical process is powered from an AC line, a Raytheon Voltage Stabilizer will permanently eliminate all of the detrimental effects caused by AC line voltage fluctuations. Made for all commercial voltages and frequencies, single or three phase.

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Write for Bulletin DL48-71 JE describing Raytheon Stabilizers.

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TENTH ANNIVERSARY

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EISLER ELECTRIC CORP. • 544 39th ST. • UNION CITY, N. J.

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Model 505 Artificial Ear and Model 300A Voltmeter

Manufacturers, research workers, otologists, service agencies and laboratories will find this combination ideal for accurately measuring the efficiency and frequency response characteristics of telephone and hearing-aid receivers under the same conditions which exist when the receiver is worn on the ear. The Model 505 Artificial Ear has been completely redesigned, simplified and reduced in cost. The Model 300A Electronic Voltmeter will be found extremely useful around the shop and laboratory for other measurements. Voltmeter range .001 to 100 volts, 10 to 150,000 cycles, logarithmic scale, AC operation. Adapters can be furnished for various types of hearing-aid receivers. In use by leading manufacturers and U. S. Government departments.

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Vacuum Tube Protection

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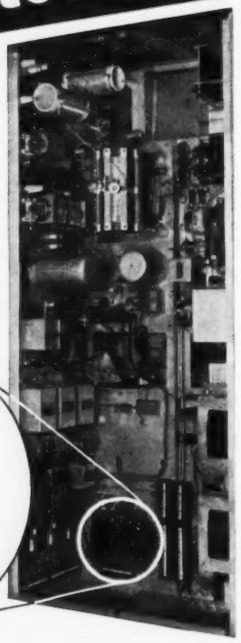
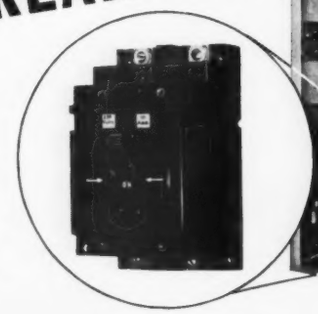




These accurately calibrated, factory set and adjusted circuit breakers are used in many N.B.C. Studios for the protection of vacuum tubes. They increase tube life, eliminate the need for costly fuses and resultant interruption of broadcasts due to their failure. The device can be reclosed immediately after opening for overload or short circuit. Heinemann Circuit Breakers are made in ratings from 50 milliamperes to 50 amperes.

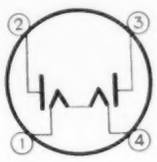
HEINEMANN CIRCUIT BREAKER CO.

97 PLUM ST. - - - - TRENTON, N. J.

Type 5X3

FULL-WAVE high vacuum rectifier, filament type, glass envelope, 4 pin base.

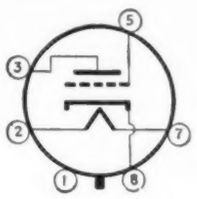
E_f = 5.0 v
I_f = 2.0 amps
High voltage operation
E_{ac} = 1275 v
I_{dc} = 30 ma
Low voltage operation
E_{ac} = 400 v
I_{dc} = 110 ma
Basing 4-C



Type 6AD5 (G)

HIGH mu triode, heater type, glass envelope, 6 pin octal base.

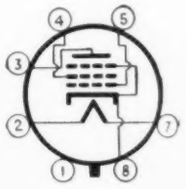
E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v
E_c = - 2.0 v
I_p = 0.9 ma
R_p = 66000 ohms
μ = 100
Basing 6-Q



Type 6AG6 (G)

POWER amplifier pentode, heater type, glass envelope, 7 pin octal base.

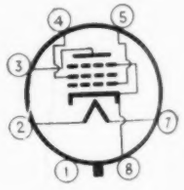
E_h = 6.3 v
I_h = 1.25 amps
E_p = 250 v (max)
E_{c2} = 250 v (max)
E_c = — 6.0 v
I_p = 32 ma
I_{c2} = 6.0 ma
g_m = 10000 μmhos
R_l = 8500 ohms
P_o = 3.75 watts (7%)
Basing 7-S



Type 6M6 (G)

POWER amplifier pentode, heater type, glass envelope, 7 pin octal base.

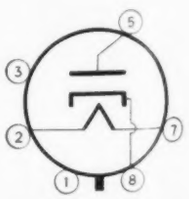
E_h = 6.3 v
I_h = 1.2 amps
E_p = 250 v
E_{c2} = 250 v
E_c = - 6.0 v
I_p = 36 ma
I_{c2} = 4 ma
g_m = 9500 μmhos
R_l = 7000 ohms
P_o = 4.4 watts (10%)
Basing 7-S



Type 25Z4

HALF-WAVE high vacuum rectifier, heater type, metal envelope, 6 pin octal base.

E_h = 25 v
I_h = 0.3 amp
E_{ac} = 125 v (max)
I_{dc} = 125 ma (dc)
E_{drop} @ 125 ma = 12 v
Basing 5-AA



THE ELECTRON ART

Among the subjects discussed in this month's review of the technical literature are applications of sound in the theater, getters, solar components of cosmic rays, and an impedance bridge

Sound in the Theater

A SUBJECT OF considerable interest is discussed in the January, 1940 issue of the *Journal of the Acoustical Society of America*, by Harold Burris-Meyer. The article is entitled "Sound in the Theater," and it discusses research in the application of sound to the stage performed by the author at Stevens Institute of Technology and at various legitimate theaters. Of the two significant components of the show, visual and auditory, one, the visual, has been subject to control and by the same token is flexible enough to give considerable scope to the artist in the theater. All the audience sees depends upon the light originating on or reflected from the stage. The artist in the theater not only has a flexible tool in light, he has a considerable body of knowledge which makes it possible for him to get definite predictable results with the visual components of the show. With respect to the auditory components of the show, however, we are still in a sub-primitive condition. We have been handicapped in our effort to control sound by limitations inherent in the source. A harp can only play so loud, a singer sing so high. Prop wind comes only from where the wind machine is placed. The Pilgrim's Chorus can move only so far. The research program was first devoted to the removal of the limitations on the control of sound so you can have the kind of sound you want, where you want it, when you want it and the way you want it, and second to the exploration of the means by which audience responds to the auditory aspects of the show may be discovered.

If the limitation on the control of sound in the theater is removed, there must be learned what sound must and can do in the theater. The uses of sound were known centuries ago. Control limitations only narrowed their scope. First the actor must be heard. After that sound can be used to establish local atmosphere and moods and as an independent arbitrary emotional stimulus, as an actor to reveal character to advance the plot all these independently or counterpointing or reinforcing their equivalent in the visual component of the show. It must also be known which aspects of sound are theatrically useful and it is apparent at once that there isn't any aspect that isn't. They all must be controlled.

The legitimate theater has a different size audience almost every night and a different set almost every scene. The acoustic variations thus introduced are obvious. Unless they are provided for in the design of the theater, the house is obsolete before the curtain ever goes up. It is suggested by Mr. Burris-Meyer that theater designers give consideration to Sidney Wolf's precepts to the effect that the theater of the future will be acoustically dead and all sound will be distributed and given the requisite reverberations by thermionic amplification.

The author gives little information about the apparatus used because he says the experimental apparatus is completely redesigned and rebuilt as often as a problem comes along which can't be solved with the equipment available. Mr. Burris-Meyer concludes his paper with an admonition. "If you can't reproduce sound well enough to prevent the audience guessing that you have a sound system, throw the system out. Get your dramatic effect some other way. You can't escape sound. Badly handled sound is worse than scenery that falls down. It destroys utterly any illusion the actors have managed to create."

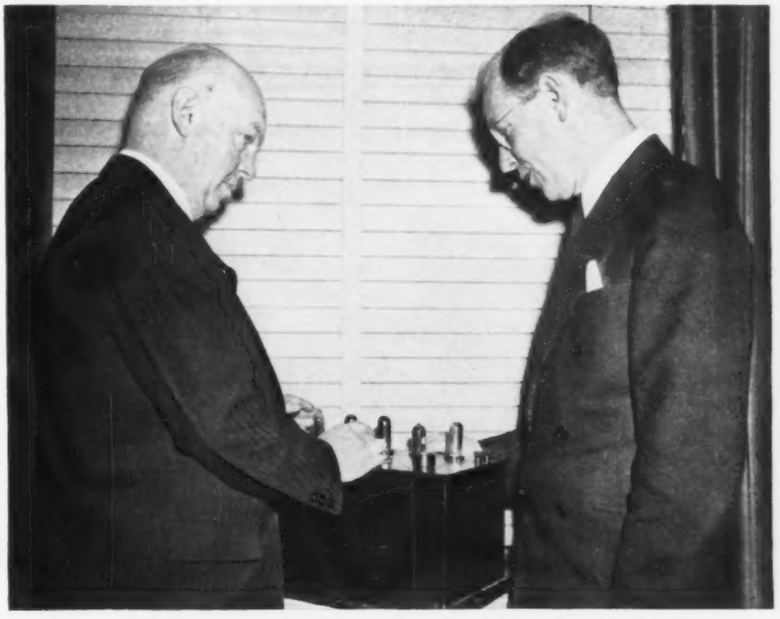
• • •

Gettering Powers of Various Metals

AN ARTICLE OF INTEREST to vacuum tube engineers and others working with high vacuums appears in the February 1940 issue of the *Journal of Applied Physics*. Its title is "An Investigation into the Gettering Powers of Various Metals for the Gases Hydrogen, Oxygen, Nitrogen, Carbon Dioxide and Air" and the authors are Louis F. Ehrke and Charles M. Slack. The metals investigated include magnesium, aluminum, barium, misch metal (active constituents are largely cerium and lanthanum), thorium, uranium, and zirconium. Barium was tested in several of its various commercial forms.

The gettering powers of diffuse layers of the metals produced by vaporizing the getters in the presence of a gas and the bright deposits produced by vaporization in a vacuum are compared and the superior results obtainable from the first mentioned confirmed. The effect of temperature on the keeping powers of the various getters is discussed. Aluminum and mag-

FREQUENCY MODULATION BEFORE THE FCC



Edwin H. Armstrong (left) explaining his method of noiseless broadcasting to James L. Fly, chairman of the Federal Communications Commission during the FCC's recent hearing on frequency modulation. One of the first superheterodyne receivers, developed by Major Armstrong, is being examined. A full report of hearing appears on page 14

THEN *[1930]*

as

NOW *[1940]*

TENTH ANNIVERSARY

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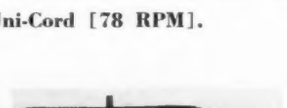

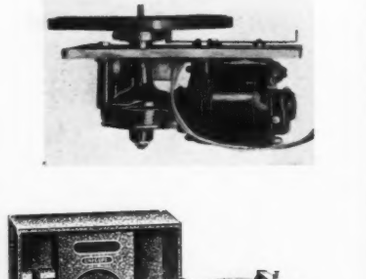

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INGLEWOOD, CALIFORNIA, U.S.A.
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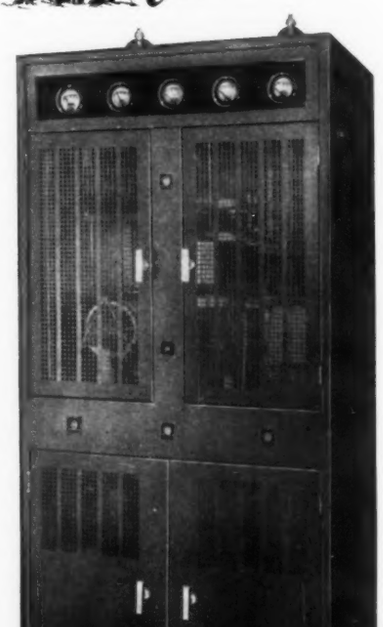
the 8-foot stop depressing the middle A key gives the expected tone frequency of 440 cps. The same key with the 16-foot stop gives the octave below and the 4-foot stop the octave above middle A.

In this case there are seven stops which can be quickly set up: (1) 16 feet alone; (2) 8 feet alone; (3) 4 feet alone; (4) 16 feet and 8 feet together; (5) 8 feet and 4 feet together; (6) 16 feet and 4 feet together; (7) 16 feet, 8 feet, and 4 feet together. Other combinations take into consideration the bass and treble tone controls. A general objective is to determine the thinnest timbre (rich in upper harmonics) and the thickest timbre (strong fundamental and weak in overtones) and divide the stops between these extremes. Another desirable pair of stops is (1) strong volume treble section tapering down to weak bass section; (2) the reverse. Also the 16 feet, 8 feet, and 4 feet stops may be combined in percentages other than 100 or zero when the separate channel mixing system is used. It is impractical to give more specific directions on setting up the timbres since tastes and the instrument itself vary so much. That is, one instrument may have just one bank of reeds while another may have a half dozen or more.

To aid setting up the timbres, one button of the switch should be selected to throw on manually operated controls for each reed bank, the bass and treble tone controls and volume control. Thus one may mix the tones at will and use this arrangement to compare with the stops previously set up. The six knobs of the potentiometers (assuming separate channel system for inputs) may be inside the console, or left outside for the musician playing the finished instrument to modulate from one timbre to another in continuous fashion rather than to break up the tone continuity by pushing another button to obtain a different timbre.

The loudspeaker volume output for a given gain setting should be about the same for all the stops, since the swell pedal can cover the full range from minimum to maximum undistorted amplifier output.

It is hoped that this general description will be found sufficiently clear and complete to enable the experimenter to carry out the construction of an electronic organ.



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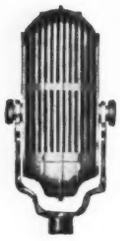

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nesium and misch metal are the most active getters in the presence of mercury vapor, although the commercially available forms of barium may make it more suitable for this purpose.

• • •

Solar Component of Cosmic Rays

"SOLAR INFLUENCES on the Cosmic Ray Intensity at High Elevations" is the title of an article by S. A. Korff appearing in the January 1940 issue of the *Journal of Franklin Institute*. In an effort to determine whether any component of the cosmic radiation might be of solar origin, balloons carrying cosmic ray measuring equipment and automatic radio transmitters were sent into the upper reaches of the earth's atmosphere. Ascensions as high as 80,800 feet were made. The article discusses the results of four such flights, two during the daylight hours and two at night.

A solar component might be expected to make its presence known by a day to night variation in the intensity of cosmic radiation or as an increase in intensity during periods of disturbance on the sun's surface such as during a solar flare. The variation of the solar component measured in these tests is to distinguish from the well known diurnal variation which occurs at sea level and is believed to be of terrestrial origin. The variation in the cosmic ray intensity at high altitudes investigated here was less than the experimental error of 2 per cent and was estimated to be about 1.5 per cent which indicates that the sun is the source of a small portion of the cosmic radiation.

• • •

A Direct-Reading Impedance Bridge

FREQUENTLY WHEN WORKING with low frequencies the engineer must determine the impedance of a circuit at a definite frequency. In such a case the circuit elements as such have little meaning because the impedance should be thought of as an entity Z rather than consisting of components R, L and C. In this regard it is well to note that most bridges measure the component

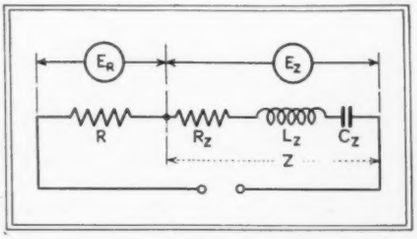

Fig. 1—Impedance measurement by comparison with a known series resistance

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HIGH OUTPUT—models available with 1 to 5 watts output.

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CLOSE SCIENTIFIC CONTROL of all specified characteristics,
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RIBBON—rolled to less than .0001" thickness

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44 GOLD ST. NEW YORK

elements and the value of Z is obtained only after a series of calculations. Mr. L. Chrétien in an article on "Direct-Measuring Impedance Bridge" in the July 1939 issue of *L'Onde Electrique* discusses this problem and suggests a solution.

The simplest method of measuring impedance is by comparison with a known series resistor. The combination is operated at the desired frequency

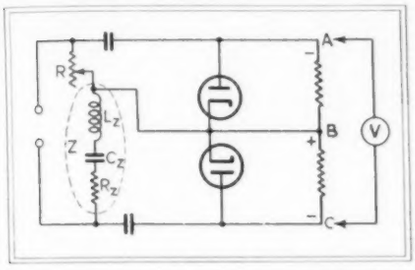

Fig. 2—Circuit to overcome phase difference difficulties

and the voltages across the two components are measured. The relation for the impedance is

$$Z = R \times E_z/E_r.$$

It is essential to use instruments of good accuracy and power as pure as possible. It is desirable to use a generator which is known to yield lower than 2 per cent harmonics at all frequencies above 100 cps.

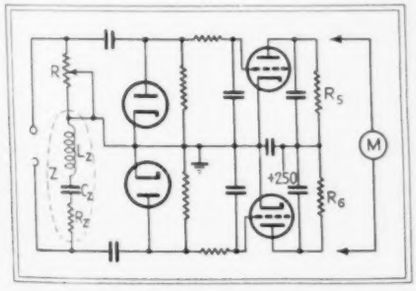

Fig. 3—Complete circuit diagram of the impedance bridge

It is not feasible to use the circuit shown in Fig. 1 as voltages E_r and E_z are neither in phase nor opposition. The arrangement of Fig. 2 overcomes this difficulty. When $R = Z$ there is no voltage difference between the points A and C, the voltages applied between A and B and between B and C are of the same magnitude and of opposite phase. The circuit of Fig. 2 can be modified to that of Fig. 3 through the use of two triodes. Equilibrium is obtained by means of milliameter M which holds its zero position when the bridge is not energized, assuming that the tubes have identical characteristics. Furthermore the readings are not affected by voltage variations of the feed network since both tubes are symmetrically connected and consequently do not affect the balance point of the galvanometer.

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Speakers

For

Consistent Quality

So much is said about the virtues of MASS PRODUCTION that we are often led to believe it is an *end* in itself rather than the *means* to an end.

Although utilizing the many advantages of straight line production, the management of OXFORD-TARTAK RADIO CORP. has constantly insisted upon careful and painstaking craftsmanship in the production of every OXFORD SPEAKER.

This insistence upon care has evolved a code of excellence within our organization which guarantees a product of unsurpassed quality. This is the end to which Oxford constantly aspires.

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Our years of service to the Radio and Sound industries is proof of the constancy of Oxford quality. Oxford speakers are

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Filter Set

38 ELECTRICAL FILTER COMBINATIONS

for acoustic and vibration testing

THIS portable unit (measuring 19½" x 12¼" x 9⅜") permits segregation of high frequencies, low frequencies or octave-width bands at half-octave intervals from 50 to 4800 cycles per second.

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ACCURACY PLUS AT LOWER COST

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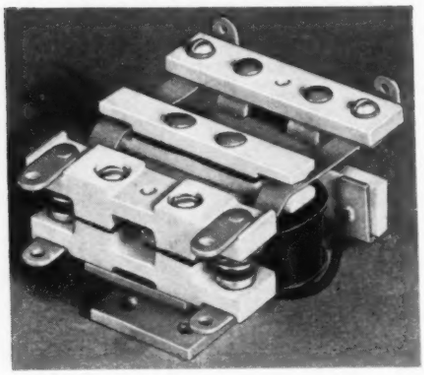
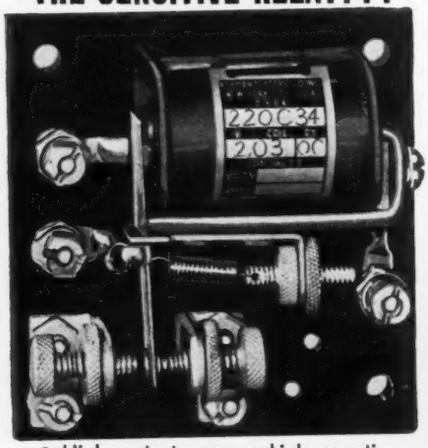
NEW! THE 25 RELAY . . .



• Rugged, compact relay with low power consumption of 1.5 watts and high power output of 2,000 watts. Coin silver contacts—1/4" Diam., cantilever spring action, self-cleaning wipe, Alsimag non-hygroscopic insulation, rugged, compact, foolproof.

THE SENSITIVE RELAY. . .



• High contact pressure, high operative speed and full armature balance in any position. Single pole, double throw, C type coin silver contacts; rated to carry 2 amperes at 110 volts. Precision adjustment. Coil will carry 3 watts without overheating. Available for requirements varying from 2 to 50 milliwatts input, and loads as high as 1,000 watts.

Cut production as well as experimental costs by specifying Kurman relays for the next job. Write today for descriptive literature; no obligation.

KURMAN ELECTRIC CO. INC

241 Lafayette Street
New York, N. Y.

Time Checking

"CHECKING THE ACCURACY of New York City Telephone Time Service" by F. Ireland appears in the March 1940 issue of *The General Radio Experimeter*. The New York Telephone Co. for five cents, will tell anyone in New York City who will call MEridian 7–1212 the correct time within five thousandths of a second. The average person asking the time has no need for this highly precise time service, but it is provided for the benefit of jewelers, astronomers and others who may have use for it. To check the accuracy of the service a visual stroboscopic device, the Time Comparator, was developed.

The instrument is essentially a 113-kc amplifier which flashes a Strobotron lamp at the beginning of each Arlington time signal and at the beginning of the time tone sent to the telephone subscribers. The flash shows through a slit in a disk turning once per second and any variation in the time as compared to the Arlington signal is measured by the space between the flashes. The one-hundredth second scale graduations surrounding the rotating disk are three-sixteenths of an inch apart. The narrow slit permits reading to half-divisions or five thousandths of a second.

The time is checked each hour that the Arlington time signals are transmitted. The time source of the Time Bureau is the crystal clock at the Bell Telephone Laboratories and therefore the stability and accuracy transmitted to the bureau are unquestioned. The Time Comparator is the final check on the operation of several miles of cable, the clocks and the pulse control relays.

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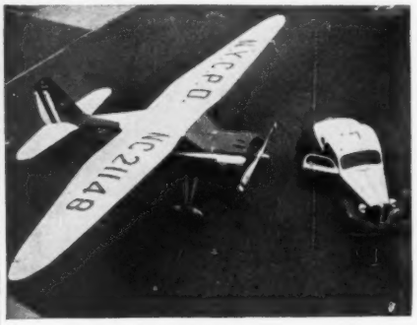
AIRCRAFT RADIO AIDS IN TRAFFIC CONTROL



New York City's brand new Stinson police planes have taken on as an important duty the control of heavy week-end and holiday traffic from the air. From a vantage point high above the highways, the planes scout around and find spots where traffic is most congested as well as where congestion is least. By means of two-way radio service, this information is sent to police cars on the ground who can then assist in rerouting traffic

Electric Fence Controllers

A PROBLEM of increasing importance during the past few years is the energizing of electric fences. The fences are used to control the movements of cattle and must not endanger either the lives of cattle or humans. A booklet covering this subject entitled "Electric Fence Controllers" was written by F. Alton Everest of the Oregon State College Engineering Experiment Station with special reference to equipment and methods developed for measuring the characteristics of such fences. The booklet briefly reviews the several types of apparatus used to energize the fences with the emphasis on safe operation. Most of the space is devoted to equipment and methods for the measurement of the electrical phenomena which take place in the energized fence.

• • •

Progress in Radio Broadcasting in England

THE OUTSTANDING ADDITIONS on the transmitting side of radio broadcasting development in England during the months of 1939 prior to the outbreak of war in Europe were the high power transmitting station at Start Point in South Devon, and the medium power station at Clevedon, near Bristol. Both of these transmitters were designed and constructed for the B.B.C. by Standard Telephones and Cables, Ltd., associated company in England of the International Telephone and Telegraph Corporation.

The transmitter at Start Point is a 100 kw installation with a directional radiator system phased on the allotted wave length of 285.7 meters. The system consists of two mast radiators each 450 feet in height spaced $\frac{3}{8}$ of a wave length apart and so phased as to obtain the desired horizontal polar diagram. Each mast is divided at a height of 310 feet by a compression insulator bridged by a suitable impedance. The medium power station at Clevedon, 20 kw was equipped with an omni-directional mast aerial 375 feet high.

The introduction of these two stations will give a reliable service of an alternative Regional program to some 3,000,000 living on the South and Southwest Coasts of England or in the inland area adjoining.

Orders have been placed for two new Regional transmitters each of 120 kw, the maximum power permitted by the new Broadcasting Convention at Montreux. These were intended for service at Brookman's Park (London Regional) and Moorside Edge.

Developments in quartz crystal technique applied to crystal oscillators of extreme accuracy led to the installation of independent crystal drives at broadcasters sharing a common wave length and resulted in greatly improved synchronization between them. In 1939 this system of crystal drive was ex-

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● Goat Tube Shields are one step ahead . . . because 1—they meet the exacting needs of changing tube and set design . . . 2—they incorporate the soundest features of tube engineering and design . . . 3—they are available for every conceivable requirement. All of which have helped to make Goat Tube Shields the most widely used of any independent manufacturer. Bring your tube shield problems to Goat for quick, easy, economical solution.

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The No. 136 and 137 Series also have four types of terminals with same terminal arrangements as No. 135 Series. Made up in panels of two or more terminals.

Our line of standard parts is constantly being increased to give you the most complete service for Terminal Panels, Terminals, Plugs, Sockets, etc. Specials also made to your blue print. Write for new catalog today. Address Dept. 10.

HOWARD B. JONES
2300 WABANSIA AVENUE,
CHICAGO ILLINOIS

tended to the remaining Regional stations in England working on exclusive wave lengths.

The new studio center at Queen Margaret College, Glasgow, second largest in Great Britain was inaugurated late in 1938 and has given splendid service throughout 1939. It includes ten new studios including one which is large enough to handle an orchestra of 100 musicians.

In order to cover the increased requirements of existing zones and the extension of the Overseas short wave services from England to additional parts of the world, new aerial arrays were constructed at the Overseas short wave station. Two high power transmitters for the short wave service were brought into service in February and another transmitter was ordered in July. This brings the total number of high power short-wave transmitters in the Overseas service to six.

Considerable further progress was made in England in 1939 in the technique of television, and the number of television outside broadcasts was greatly increased. Pictures were transmitted sucessfully over ordinary telephone lines up to distances of four miles and this enabled many program sources to be linked to the special balanced pair television cable which circles the central part of London.

For outside broadcasts, passed by radio link from one of the two mobile units consisting of scanning and ultra short wave transmitting vans, the re-

• • •

JAPAN GETS ELECTRON MICROSCOPE

Prof. Sugata of the Osaka Technical College with the electron microscope which the College has recently acquired. The microscope is very similar in appearance to that developed by Ruska and his associates of the famous Siemens concern in Germany

27-145 MEGACYCLE RANGE
(11.1-2.07 METERS)
AMPLITUDE/FREQUENCY MODULATION

Model S-27 is the first general-coverage U.H.F. communications receiver to incorporate Frequency Modulation reception. Covers 3 bands: 27 to 46 mc; 45 to 84mc; 81 to 145mc. Switch changing from FM to AM reception. Acorn tubes in R.F. and newly developed converter system. High gain 1853 tubes in I.F. stages. Beam power tubes and 6C8G phase inverter in A.F. Amplifier. Limiter tube provides full limiter action on signals of approximately 5 to 10 microvolts in F.M. operation. 955 plate-tuned oscillator. I.F. selectivity automatically sharpened to receive amplitude modulated U.H.F. signals or broadened for wide band frequency modulated signals. Front panel controls: R.F. gain control. Band switch. Antenna trimmer. I.F. selectivity (air tuned iron core) control. Volume control. Pitch control. Tone control. S-meter adjustment (meter calibrated in S and DB units.) AVC switch. Beat oscillator switch. Automatic noise limiter switch. Amplitude/Frequency Modulation switch. Send-receive switch. Phone jack.

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TO YOUR PROBLEMS

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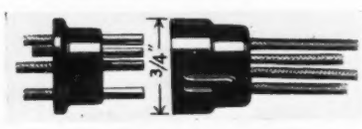
Typical answers to such problems of—

● A large radio set manufacturer needed a well insulated compact connector for a phonograph motor that would meet underwriters requirements for 110 volt duty.

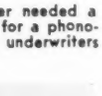


★ An Alden stock item type 502P and F supplied with leads met all their requirements and others which had not been anticipated at the time of the original request. *F. A. This can also be supplied with three or four circuits.*

● A wire communication requested a special dial lamp socket for a particular application where the number to be used was small.

★ Temporary tools were made and the small quantity ordered was shipped promptly. It later developed to a point where production quantities were ordered.

● A relay manufacturer required a base for mounting a sensitive relay to plug in an octal tube socket.



★ An Alden stock item type 108 plug was recommended and adopted. The customer was also advised that plugs of the same dimensions were also available in 4-5-6-7 prongs which were later adopted for other type relays.

● A radio set manufacturer making a combination radio-phono recorder set required a neat appearing shielded plug and socket for a microphone cable.

★ Alden supplied a stock grounding ring socket and shielded plug in an antique bronze finish complete with the shielded microphone cable.

If you have a problem involving wire assemblies, cables, connectors, dial lights, special moldings, or other small assembly, check our data sheets and then with the factory for the best possible solution.

Send for the latest information on television components.

ALDEN PRODUCTS CO.

714 Center St. Brockton, Mass.

ceiving station established on Highgate Hill in 1938 as an alternative to reception at Alexandra Palace was put into general use. The signals received were conveyed from Highgate Hill to Alexandra Palace, the television broadcasting center, at vision frequency by the neighboring balanced pair television cable. The receiving aerial at Swains Lane, Highgate, was a two-element array half way up a mast of 250 feet, but experiments were begun with a rotatable receiving array for horizontally polarized waves with which a gain of about 10 db was anticipated.

Considerable progress was made in the design of the new Super-Emitron camera by Marconi—E.M.I. Experiments with a cathode ray type of view finder were most promising. This view finder consists of a small cathode ray tube fed directly from the scanning equipment. The camera man thus sees the picture in his camera as it is actually transmitted instead of on a small optical view finder as formerly.

During 1939 the British Broadcasting Corporation co-operated further with the Post Office and with the British Standards Institution on the subject of the electrical interference with radio reception and agreed standard specifications were issued by the B.S.I. on "Radio Interference Suppression for Automobiles and Stationary Internal-Combustion Engines" and "Radio In-

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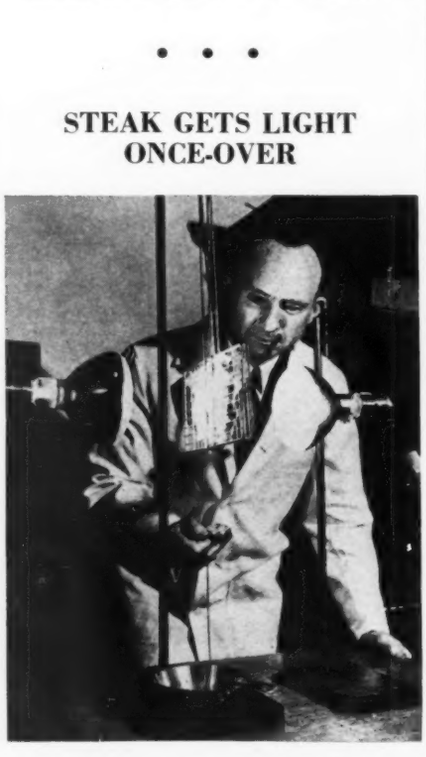
STEAK GETS LIGHT ONCE-OVER



Placed in a grill between two 250-watt reflector type drying lamps, a prime cut of filet mignon sizzles as J. D. Hall, Westinghouse engineer at Bloomfield, N. J. times the operation. The steak was pronounced well done after nine minutes of exposure to the infra-red rays produced by the two lamps shown

Balancing and Semi-Tuned Power Filters

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POWER, IGNITION AND ANTENNA CIRCUITS

★ Units available for: Airplanes, airships, marine ships, fighting tanks, police radio, government and industrial research laboratories, colleges and many other uses.

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No shielding required
Light in weight
Easy to install
Inexpensive
Efficient

The Whisk patented glow-gaseous discharge tube combined with the balancing unit is designed to overcome electromagnetic and electrostatic disturbances as encountered in tropical countries.

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INVALUABLE FOR DETERMINING VIBRATIONS

Used by leading machinery, aircraft and diesel engine builders. Colleges, laboratories and construction companies.

Model 29 unequalled for determining amplitude of vibration and frequency analyzation. Measures amplitude of vibration in four ranges covering .0001 to 1".

Model 11 same as Model 29 except minus frequency analyzer, ruggedly built for factory use and production line. No calculations, direct calibration, only one control.

NET Model 29—$290.00 F.O.B.
Model 11—$150.00 F.O.B.

Write for catalogue on other products.

TELEVISO Co.

1135 North Cicero Avenue
CHICAGO U. S. A.

terference Suppression for Trolley-busses and Tramways". The previous specification for the "Limits of Radio Interference" was revised and re-issued. Attention was also directed to the problem of interference caused by electromedical equipment on short and ultra short wave lengths.

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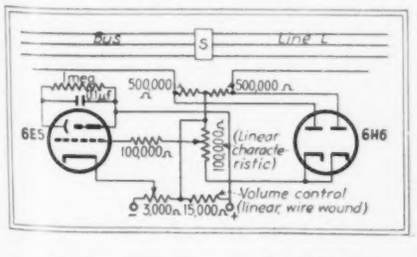
Synchronism Indicator

THE APPLICATION OF a Cathode-ray tube circuit to the problem of synchronizing a 132,000-volt line to a bus, is described in an article entitled "Cathode Ray Type Synchronism Indicator," by Frederic S. Beale, in the March 1940 issue of *Instruments*. A type 6E5 tube is used and the circuit is shown in the accompanying diagram. The small size of this tube enables its installation to be made in the best position for observation by the operator. Also because of its small size it may be duplicated at other convenient points by connecting additional tubes in parallel with it.

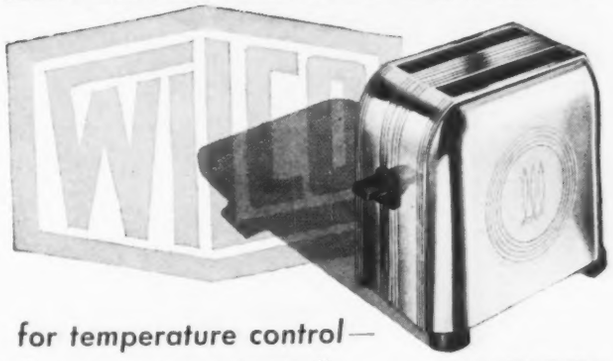
In the diagram, the line *L* is synchronized to the bus by means of the switch *S*. To a phase conductor of the line a static collector wire is electrostatically coupled, and another static collector wire is similarly coupled to the corresponding phase conductor of the bus. The potential developed in each of the pickup wires is proportional to and of the same frequency as the potentials of the bus and line to which they are coupled. Before the switch can be closed the frequency and phase relation in the bus and in the line or in the pick-up wire must be identical. During synchronism there is no difference of potential in these two pickup wires and therefore the adjustment is made such that the 6E5 target shows a green light pattern with only a thin black shadow. With the line of the bus out of step the thin line of shadow spreads out with a more or less rythmic opening and closing motion. The 100,000-ohm resistor is set so that the shadow covers approximately a 90 degree sector of the circle.

The indication given by this instrument does not in itself show whether the incoming line has a frequency which is higher or lower than the bus to which it is to be connected. If this information is required it may be obtained by the addition of an amplifier tube to provide the power needed to operate the rotation indicating device.



Circuit diagram of synchronism indicator for power lines

LEADERSHIP!



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Puzzled over the proper contact materials for your product? Then do as the McGraw Electric Co. — Maker of "Toastmaster" Products — and thousands of other industrial leaders do. Consult with — Wilco pioneer in the development of scores of varying contact materials.

Benefit from 26 years of experience in the research, manufacture and sale of every known kind of electrical contact. Utilize products that have *proved* their accuracy and reliability under every conceivable kind of laboratory and field test. Write for "Wilco Blue Book of Thermometals"—The H. A. Wilson Co., 105 Chestnut Street, Newark, N. J. Branch Off.: Detroit, Mich., & Chicago, Ill.

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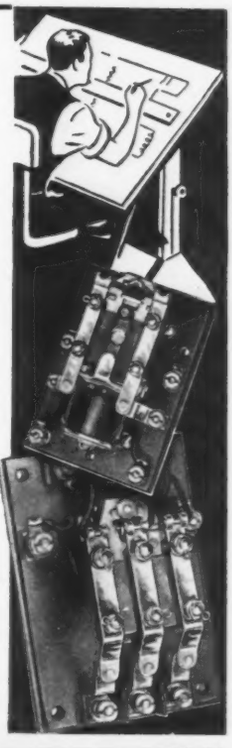
WE FIT THEM TO YOUR JOB

... AND THAT'S HOW RELAY DEPENDABILITY IS ASSURED

There is one right way to buy relays: that is, to make sure they are designed right in the first place, then specifically adopted to your application. This is where Dunco comes into the picture in a big way. Backed with one of the largest lines of quality relays, timers, etc., and with years of practical experience in fitting them to the specific needs of leading users, Dunco engineers are in an enviable position to help you get the most for your relay dollars in terms of dependability and long, trouble-free performance.



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The Type 6C Measuring Set provides an accurate and rapid method for measuring the transmission characteristics of networks at audio frequencies.

This new set has the following outstanding features which contribute to its usefulness in the radio broadcasting field.

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★ FREQUENCY RANGE: 20 to 17,000 cycles.
★ IMPEDANCES: Dial selection of useful network input and load impedances.
★ MISMATCH ADDITIONS: No additions necessary for change of impedance.

TYPE 6C TRANSMISSION MEASURING SET..$325.00

Write for additional technical information.

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The Type 6C was developed in co-ordination with the engineering department of the Columbia Broadcasting System.

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Specialists in Equipment for the manufacture of Neon Tubes, Radio Tubes, Incandescent Lamps, Photo Cells, X-ray Tubes, etc.
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Is it complete?
Are you expanding it?
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Naturally, you are anxious to secure the most suitable man or men available. You want men with the special training that will make them an asset to your organization. You can contact such men through a Position Vacant advertisement in the Searchlight Section of ELECTRONICS

Coaxial Loudspeakers

(*Continued from page* 35)

operator and be heard in the receivers.

The characteristics of the studio microphone are, of course, as important as those of the loudspeaker in determining the overall performance of a system. This obvious fact, however, is sometimes overlooked in passing judgment on a loudspeaker's rendition of broadcast reception. The layman's beautifully straightforward and simple theory that anything wrong with the sound must be the fault of the loudspeaker because that is where the sound comes from seems sometimes to be shared by those who are not so lay. However, considerable effort was spent on loudspeakers and circuits before it was fully realized that the reason for the devastating shrillness of the violins resided elsewhere.

There are probably still in use today many dynamic microphones of an older type whose field calibrations disclose peaks as large as 8 db in the high frequency range. Such irregularities cannot be dealt with successfully by electrical equalization because at least part of the high frequency rise is a function of the angle of incidence of sound upon the microphone. The presence of these defects is usually unsuspected when listening with ordinary radio receivers having a generally falling high frequency response and nearly complete cut off at 5000 cps. They are sometimes distressingly revealed, however, when one listens over an extended frequency range system known to be free from significant irregularities. When talkers of the type inelegantly but expressively characterized as "spitty", speak close to such a microphone the results over a high fidelity receiving system sometimes approach the absurdity of a "sound effect". Another type of talker appears to deliver a strong air current along with speech (no political references intended) which at close range produces eddies within or around some microphone structures and gives rise to a disturbing hissing and roaring accompaniment. At the other end of the frequency scale are the bass boosting effect of talking too close to an unequalized ribbon microphone and the

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● The combination of high tensile strength that assures a lasting bond, and faster, cleaner work made possible by quick-acting flux of pure water white rosin, has given Gardiner Rosin-Core Solders an outstanding reputation for efficiency and economy on radio work by expert or amateur. Yet, due to modern production methods and big sales, Gardiner Solders cost less than even ordinary kinds. Made in various alloys and core sizes . . . and in gauges as small as 1/32 of an inch . . . in 1, 5 and 20 lb. spools.

Gardiner METAL CO.

4889 S. Campbell Avenue Chicago, Ill.

carpet beater illusion produced by this same combination and a talker who bears down heavily on "puh".

There lately has been much improvement in available microphone characteristics. The miniature condenser microphone originally designed as a measuring tool some years ago by Harrison and Flanders[4] is now being used in commercial practice. Experience with this instrument in measurement work and as a sound pick-up in aural tests of loudspeakers has been very gratifying. When equipped with a small wind screen it can be used for close talking with none of the undesirable effects mentioned above. Later microphones of the uni-directional type also appear to offer possibilities of more natural overall results.

One does not realize how far studio conditions of sound pickup sometimes depart from those of usual direct audition until he has listened to a large number of different programs over a system of known high fidelity. One of the problems of microphone placement in the past appears to have been the difficulty of getting the violins in an orchestra to "come out" in the reproduction as afforded by ordinary loud speakers. Consequently, the tendency has been to place these instruments close to the microphone. Now, when we listen to such an arrangement over a truly high fidelity system, we are conscious of so much scraping and creaking noise accompanying the music that it may detract from appreciation of the extended frequency range. The explanation is connected with the fact that we seldom if ever listen to actual performances at as short distances as microphones are commonly placed. Nor are the bowed instruments the only offenders in this respect. Too often when listening to solo performances over wide range systems are we conscious of the breathing noises of singers or the clatter of the key mechanism of woodwind instruments or accordions. When the listening is done over ordinary receivers with their customarily restricted frequency range, the noises above referred to are usually not recognized because so many of their essential frequency components lie outside the receiving system range.

Noise leaking into studios and poor studio acoustics appear to be among the reasons for close-up

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microphone placement. The first of these demands the close pick-up to secure a satisfactory signal to noise ratio. In addition, studio noise is by itself more troublesome when programs are received over wide frequency range systems because the noises are reproduced with such naturalness as to be readily identified and therefore distracting, as contrasted with the generally indeterminate character of such sounds when heard over ordinary radio equipment.

It is not suggested that microphones be placed at optimum direct listening distance regardless of experience and the well known monaural difference. It is believed, however, that more natural sounding pick-up for high fidelity reception requires working toward the maximum rather than toward the minimum distance and that conditions which prevent the attainment of this end should be rectified.

The effects complained of above are, in general, the exception rather than the rule. The reception of most local station programs, even those transmitted over wire networks with a 5000 cps cutoff, is much more enjoyable over a high fidelity receiver equipped with a loudspeaker system of the type described, because the overall response of such a receiver is substantially flat over a wide frequency range, whereas the ordinary "standard fidelity" receiver is not only well on its way out at 5000 cps, but its response is not smooth.

The full possibilities of a good high fidelity receiver can only be enjoyed on present conventional broadcasting when the program is picked up locally over wide band circuits and received at high field strength. Even small dance orchestras heard under these conditions appear to take on new life and percussion instruments whose presence ordinarily would be unsuspected can be identified. Large symphony orchestras are reproduced with a thrilling degree of realism. We may expect even greater realism with the increased dynamic range promised for frequency modulation transmission systems and made possible by their low noise level.

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[1] *Jour. Acous. Soc. of Amer.*, Jan. 1931, p. 330.

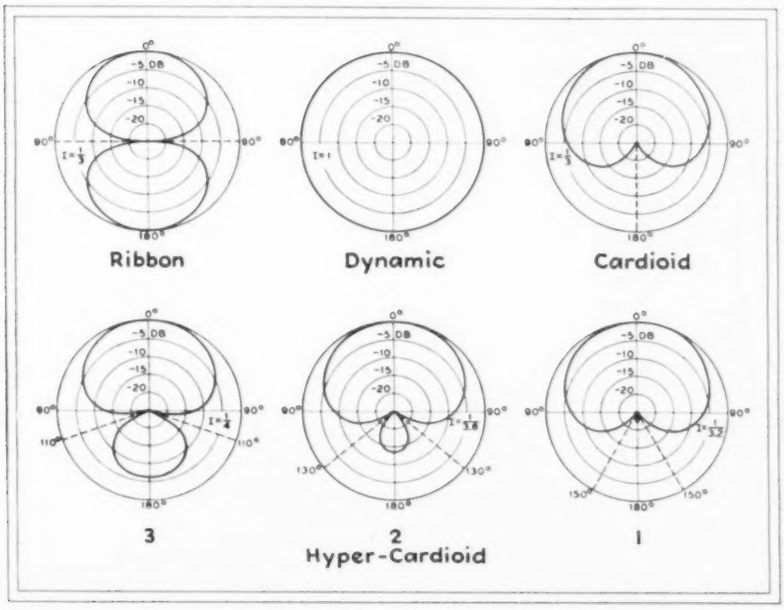
[2] *Elec. Eng.*, Jan. 1934, p. 18.

[3] *Jour. Acous. Soc. of Amer.*, Oct. 1936, p. 104. *Electronics*, April 1937, p. 24.

[4] *Jour. Acous. Soc. of Amer.*, July 1932 (Supp), p. 451.

THE INDUSTRY IN REVIEW

New Multi-Pattern Cardioid Microphone



Response patterns available with the Western Electric Multi-Mike. The hyper-cardioid patterns are obtained by varying the attenuation of the dynamic unit relative to the ribbon unit

A NEW cardioid microphone, the Multimike (Type 639B) in which the response pattern is adjustable to the studio or auditorium conditions has recently been introduced by the Western Electric Co., 195 Broadway, New York. In addition to the three characteristics available with the original cardioid microphone, i.e., the non-directional, the bi-directional and the cardioid, the new instrument provides three new hyper-cardioid patterns, each with two areas of deadness extending radially from the rear of the Multimike. The desired pattern is obtained by means of a six position switch located on the rear of the casing and which changes the degree of attenuation of the output of the dynamic element. The accompanying diagram illustrates the shapes of the various patterns and indicates the dead spots in the three hyper-cardioids. The dead areas are actually dead volumes, that is, if they could be made visible, they would appear as cones of insensitivity radiating into space from the rear of the microphone.

The frequency range is from 40 to 10,000 cps and the output is minus 84 db referred to 1 volt per dyne per sq cm. The impedance is 30 ohms. The new instrument weighs 3 pounds and 4 ounces and its dimensions are 7½ inches high by 3 1/16 inches wide by 4 1/16 inches deep. It is finished in an aluminum gray color. There is available a complete line of desk, floor and suspension stands and other accessories for quickly changing from one type of microphone to another without disconnecting the cord.

The usefulness of the new instrument is apparent in reverberent halls where the hollow sound usually associated with such halls is reduced to a considerable degree. In public address work, use of the Multimike permits a material increase in the amplification before the system howls due to excessive feedback from the loudspeaker to the microphone. The increased amplification permissible with the use of the Multimike increases the maximum allowable distance from the microphone and permits the speakers or performers more freedom of motion. In public address work it is only necessary to point the dead spot of the microphone at the loudspeakers to reduce the feedback. In studios which are not completely sound treated, the dead spots are pointed at the sources of echo to reduce the undesired reverberation.

As the response pattern of the microphone is advanced through its various phases, an increasing discrimination against random reverberation is noted. This effect is at a maximum in hyper-cardioid pattern No. 3, as shown in the diagram. This is the case because the directivity characteristic changes as the response pattern changes. In position 3, the sensitivity to sound from the front exceeds the average sensitivity from all directions by four times. Therefore, sound directly from the front of the microphone is favored by a factor of four to one over sounds reflected from random points throughout the room.

The usefulness of this microphone is greatly enhanced by its several types of response patterns

News

✦ The new $700,000 studio and laboratory annex of Columbia Broadcasting Company, New York City, is scheduled to open on May 15th. The annex will house seven studios, in which will be embodied every technical advance and innovations for improvement in quality of sound definition . . . A new engineering department devoted to the general commercial design and production of radio apparatus of all types, and associated products has been created by the Radio Division, Westinghouse Electric & Manufacturing Company at Baltimore, Md. This new department will be known as the Special Apparatus Engineering Section and will be under the direction of Ralph N. Harmon . . . A special design service on radio coils is being offered to radio engineers, experimenters and firms having use of a single, or many coils. Barber &

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Howard, East Ave., Westerly, Rhode Island, manufacturers of i-f, r-f, and oscillator coils and coil winders will be glad to assist by designing coils suitable to be used in radio equipment, custom built sets, radio direction finders, etc. Rewinding of defective coils or duplication of any coils needed is included in their services . . . The Hewlett-Packard Company is moving from its old quarters at 367 Addison Avenue to new and larger quarters at 481 Page Mill Road, Palo Alto, Cal. . . . The Canadian Research Institute have moved their laboratories to larger quarters at 463 Spadina Ave., Toronto, Canada. They will also increase their staff . . . The offices, laboratory and factory of Radio Development & Research Corp., will now be located at 136 West 52nd St., New York City . . . Elastic Stop Nut Corp., Elizabeth, N. J. is building a new plant on Vauxhall Road, Union, N. J. which is to be used solely for the manufacture of the corporation's extensive line of self-locking nuts . . . Stromberg-Carlson Telephone Mfg. Co., has made several organizational changes. Succeeding the late George A. Scoville as Vice President and General Manager is Dr. Ray H. Manson. Fred C. Young now becomes Chief Engineer and succeeds Dr. Manson in active charge of the engineering forces . . . Dr. Jesse T. Littleton has been promoted by Corning Glass Works to the new position of Assistant Research Director of that Company . . . The Annual joint meeting of the Institute of Radio Engineers and the American Section of the International Scientific Radio Union will be held on April 26th at the National Academy of Sciences, Washington, D. C. The program of abstracts will be available about April 15th.

Literature

F-M Transmitters. Radio Engineering Laboratories, Inc., (35–54 36th Street, Long Island City, N. Y.) have a booklet (No. 259) available which illustrates and contains information on their frequency modulation transmitters suitable for high fidelity purposes.

Mobile Equipment. A four page bulletin contains specifications and illustrations of the following products of Kaar Engineering Co., Palo Alto, Cal.: Two-way police radiotelephone for mobile service, uhf police radio transmitter, uhf police radio receiver, and two-way police radio.

Aero-Thread Screw System. Bulletin T-1 contains engineering standards and technical information on Aero-Thread screws, studs, bolts, tapped holes and nuts. Manufacturers who use magnesium and aluminum castings and forgings will be interested. Aircraft Screw Products Co., 25–12 41st Ave., Long Island City, N. Y.

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Tube Service Manual. Extensive and up to date information is contained in a 32-page "Plug-In Resistor Tube Service Manual" available for 15 cents from Clarostat Mfg. Co., 287 N. 6th St., Brooklyn, N. Y.

Blue Ribbon Resistors. Blue Ribbon resistors make a departure from the conventional tubular type of resistors. A one page bulletin illustrates and describes this new product of Hardwick, Hindle, Inc., Newark, N. J.

Bulletins. Several new bulletins available from Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa., are as follows: Bulletin 146-1 describes resistance standards, decade boxes, and special parts for electrical measurement. Bulletin 146-2 contains a number of unique bridges which are convenient for measuring d-c resistance, high and low resistance, conductivity, etc.; and bulletin 146-3 announces a large number of test sets and special apparatus used in electrical measuring, particularly in different phases of industrial work, electrical laboratories, etc.

Silver Brazing Alloys. Comprehensive information on the use of silver brazing alloys for joining metals in the marine field are contained in a reprint available from Handy & Harman, 82 Fulton St., New York City.

Cinaudagraph Speakers. A 4-page bulletin which contains quite a few illustrations and other information on Cinaudagraph speakers is available from United Teletone Corp., 150 Varick St., New York City.

Cetron Photocell. Type CE-23, a general purpose photocell is illustrated and described in a bulletin available from Continental Electric Co., Geneva, Ill. Another bulletin contains price schedules on various types of Cetron phototubes. A third bulletin contains simple photocell circuits.

Time Delay Relay. Bulletin F-2 describes the new synchronous motor driven time delay relay manufactured by R. W. Cramer Co., Centerbrook, Conn. The bulletin tells what this relay does, its uses, design, construction, etc.

Phonograph Needles. The Fidelitone phonograph needle recently developed by Permo Products Corp., (6415 Ravenswood Ave., Chicago), is described in a bulletin recently issued by them.

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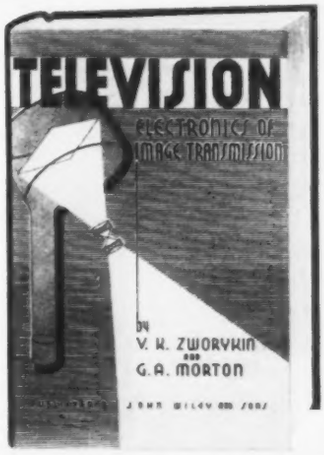

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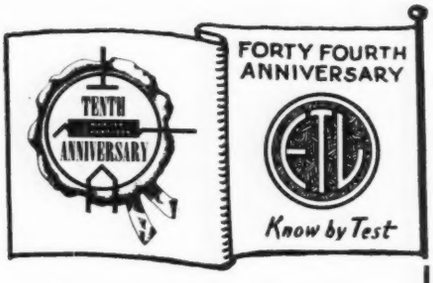

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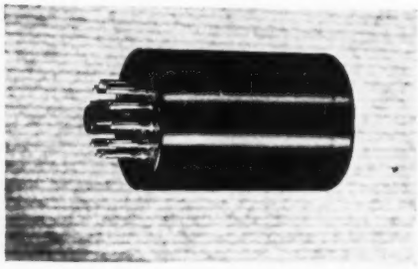
THE KENYON TRANSFORMER CO., 840 Barry Street, New York City, have announced a complete new series of transformers made in both standard and submersion proof types. They are designed to plug into an 11-prong octal socket and are neat in appearance. Units are manufactured in the following types: line to line, crystal mike to



line, low impedance source to grid, interstage transformer, and output transformers and chokes. With no dc in the winding the frequency response is plus or minus 2 db 30 to 20,000 cps. These units will find application in light portable equipment, such as aircraft, broadcasting, marine, or any other service where government specifications for submersion proof testing are to be maintained.

• • •

W2XOR FM TRANSMITTER

At WOR this frequency modulation transmitter, installed by Radio Engineering Laboratories, Inc., has been in operation for several weeks

Photoelectric Colorimeter

SEVERAL TYPES OF Lumetron photoelectric colorimeters are available from Photovolt Corp., Dr. F. Loewwenberg, 10 East 40th St., New York City. Model Kl-401 is for use in general colorimetric and turbidimetric determinations. The unit is suited for sample holders up to 1 inch. It is self-contained with built-in pointer type galvanometer; Model Kl-402 is for accurate measurement of extremely transparent liquids. Suited for sample holders up to 6 ins., and has an external point type galvanometer; Model Kl-401E is for use with monochromatic filters (abridged spectrophotometry). Suited for sample holders up to 1 inch and has an external mirror type galvanometer; and Model Kl-402E, for use with monochromatic filters and for accurate measurement of extremely transparent liquids. Suited for sample holders up to 6 ins. External mirror type galvanometer.

These colorimeters are useful for opacity determinations on paper and other translucent materials, transmission measurements on glass and other transparent products, reflection tests on surfaces, Tyndall effect measurements, and measurements with mercury-vapor light source. They operate on 110-120 volt, 60 cycle ac, for 220-240 volts, for 25 cycles and for dc.

A bulletin is available which contains complete information.

New Audio Filter Unit

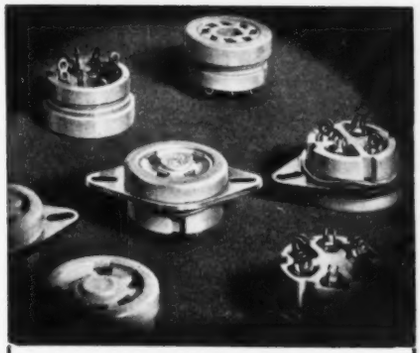
P. R. MALLORY & CO., INC., Indianapolis, Ind., announce a new audio or hum filter unit, the Mallory VF-223, which is now available for use with all single unit Mallory Vibrapacks. It was designed especially for application where voltage regulation is important, as in Class "B" audio amplification; or where the utmost in hum suppression is required as in high gain audio amplifiers.

The filter condenser is a three-section Mallory FPT-390, of 15-15-10 μf capacity, 450 working volts. The two 15 μf sections are used with the choke to form a conventional pi-section filter, while the third 10 μf section connects to a separate terminal so that, if desired, a filtered intermediate output voltage may be obtained. The filter choke is rated at 100 ma. and has a d-c resistance of only 90 ohms, resulting in a minimum of voltage drop.

Capacitors

CORNELL-DUBILIER Electric Corp., S. Plainfield, N. J., announce Type TK Dykanol capacitors for high voltage transmitter applications. The d-c working voltages range from 6000 to 25,000 in a wide range of capacity values.

Also available from C-D are a wide variety of mica capacitors for low-power transmitter application in the Types 4 and 9 Moulded Mica units. They were designed for transmitter manufacturers and amateurs.



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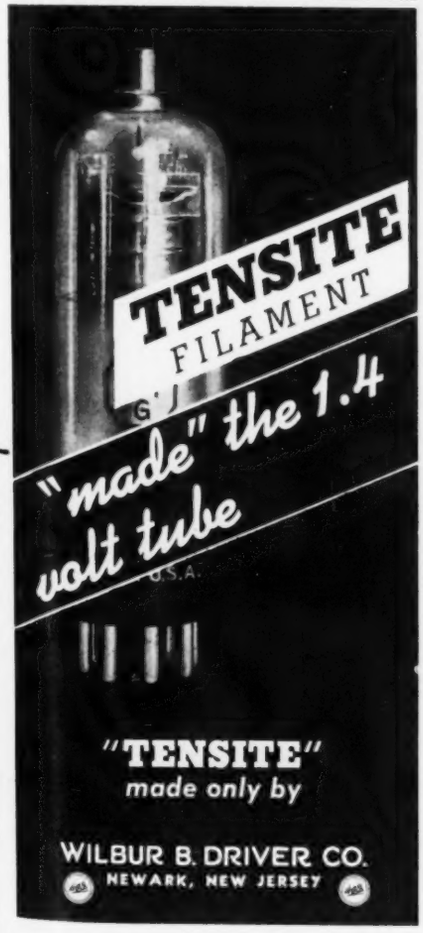

Wireless Phonograph Oscillator

AN IMPROVED and compact wireless phonograph oscillator (Cat. No. WO-6) has been announced by Bud Radio, Inc., 5205 Cedar Ave., Cleveland, O. The oscillator (size 4½x2½x2-ins.) may be attached inside the case of most record players. The circuit utilizes only one stabilized tube. It operates from either 115 volts ac or dc and is easily installed. Records may be played through any radio receiver at distances up to 50 or 75-ft.

Cardioid Microphone

A NEW CARDIOID dynamic microphone is offered by Shure Bros., 225 W. Huron St., Chicago. This new Model 555 Unidyne utilizes the "Uniphase" principle. The microphone employs a specially suspended double wind-screened moving-coil system and built-in flexible rubber cushioning to assure transverse vibration isolation. It can be tilted forward as well as rearward through an angle of 150 deg. Other important features include: true cardioid uni-directional pick-up which helps reduce the pick-up of troublesome reflections, reverberation effect, or random background noise. The Unidyne is available in 35-50 ohm and 200-250 ohm models, or in high impedance models.

Low Resistance Ohmmeter

BULLETIN 1635 just published by James G. Biddle Co., 1211 Arch St., Philadelphia, Pa., describes a "Ducter" ohmmeter with which measurements down to one millionth of an ohm are made as easily and as simply as measurements of high resistance by the ordinary "Megger" insulation tester. A battery is used to supply the necessary testing current, and there are no manipulations or adjustments, not even for the voltage of the battery. The result is indicated directly by the deflection of a pointer over a scale.

One of the most important applications for the "Ducter" is in testing air and oil circuit breakers; also switches and relays.

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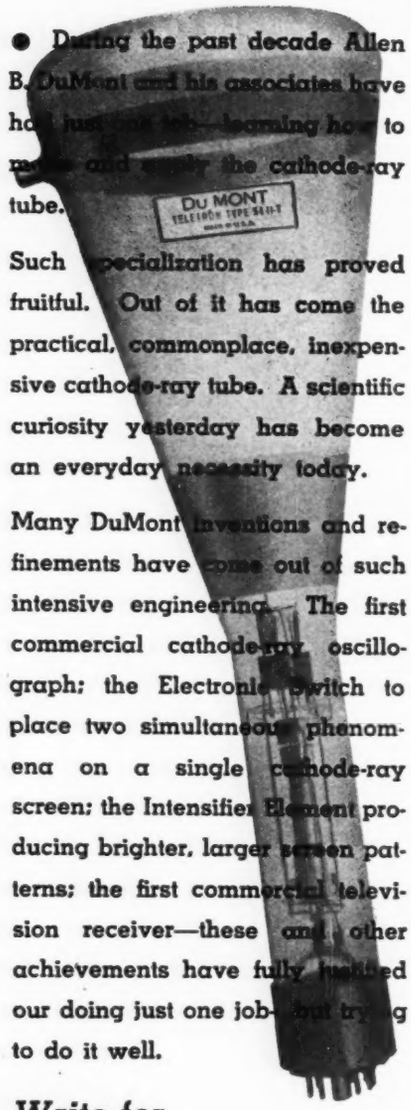

● During the past decade Allen B. DuMont and his associates have had just one job—learning how to make and supply the cathode-ray tube.

Such specialization has proved fruitful. Out of it has come the practical, commonplace, inexpensive cathode-ray tube. A scientific curiosity yesterday has become an everyday necessity today.

Many DuMont inventions and refinements have come out of such intensive engineering. The first commercial cathode-ray oscillograph; the Electronic Switch to place two simultaneous phenomena on a single cathode-ray screen; the Intensifier Element producing brighter, larger screen patterns; the first commercial television receiver—these and other achievements have fully justified our doing just one job—but trying to do it well.

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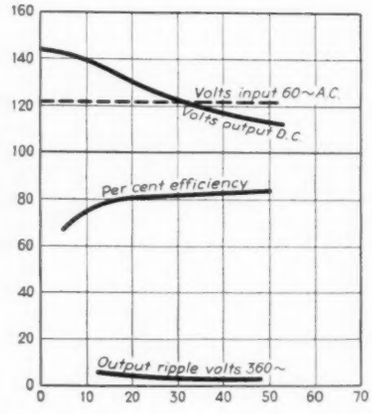
ALLEN B. DU MONT LABORATORIES • INCORPORATED

PASSAIC NEW JERSEY

Cable Address: Wespexlin, New York

Rectifiers

RECTIFIERS developed by H. J. McCreary, a consulting engineer of Chicago are manufactured by the Thomas B. Gibbs Co. expressly for him. The rectifier is a three phase bridge type, which gives six phase performance. It is designed to deliver 45 amps continuously at 115 volts dc from a 122 volt 60 cycle three phase ac supply. The ripple voltage is less than 3 volts



when the unit is fully loaded and delivering 45 amps.

No power transformers are used in this rectifier, aside from a filament transformer which consumes less than 300 watts regardless of load. Protective devices are provided which include reactors and fuses.

This unit has been used with three standard single phase transformers to supply 45 amps at 115 volts dc from 550 volts 60 cycles three phase ac.

U-h-f Oscillator

MAINTENANCE of u-h-f receivers on airplanes requires the use of a modulated u-h-f signal generator. Victor J. Andrew, 6429 S. Lavergne Ave., Chicago, manufactures and sells instruments of this type developed by United Air Lines. Fundamental frequency ranges from 49 to 154 Mc.

Studio Amplifier

AMONG THE FEATURES of Tru-Fidelity studio amplifier is the audio frequency equalizer, a refinement of the THORDARSON Dual Tone control circuit, which provides a wide choice of ranges. Although the amplifier is essentially one unit, the low level and voltage amplifier stages are isolated from the power stage and power supply, reducing hum to a minimum.

It is available for rack mounting or in a grey cabinet. A brushed steel panel makes this a most attractive instrument in any conspicuous position. Complete specifications and technical data are available in Bulletin SD-443 by writing the Thordarson Electric Mfg. Co., Chicago, Illinois, or at your local distributor.

Home Recording Needles

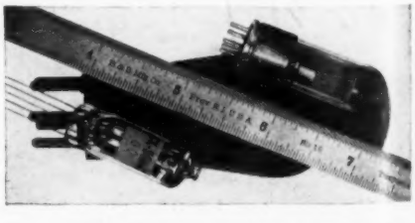
THE NEW PERMO POINT home recording needle is made by electrically welding a special alloy to specially drawn shank material, resulting in a very rugged and sturdy product which will withstand considerable abuse, yet provide exceptionally long life, with an exceedingly low surface or background noise. This new cutting needle will fit all standard recording machines, and will be found particularly useful on home type recording machines, where ordinary steel needles wear quickly, and where sapphire needles are not generally used because of their delicate construction. The needle is made with uniform radius to cut standard size record grooves.

Sound System Units

THREE NEW SOUND system units announced by RCA Mfg. Co., Camden, N. J., include: A new 25-watt amplifier (Model MI-12205) which combines higher performance characteristics with modern case styling. Advances in circuit design have achieved reduced hum. Operation is made easier by new control knobs designed to conform with the natural contour of the hand. The new two-position mixer (Model MI-12208) was designed primarily for use with Model MI-12205 amplifier when additional mixer inputs are necessary, but has applications with other types of amplifying apparatus as well; (MI-9430A) 20 watt loudspeaker mechanism has been made available as a separate unit for use where conditions require a large, flat baffle area. The unit can be attached to a small diameter opening in a wall or baffle, and the new acoustic throat makes possible as even distribution of high frequencies throughout the distribution angle of the baffle.

Raytheon Tubes

TUBES FOR FREQUENCY modulation and for hearing aids are among Raytheon's most recent listings. There are 4 of the hearing-aid tubes and they are very small, consuming little power and deliver reasonable and useful output. The American Phenolic Corp., 1250 Van



Buren St., Chicago, makes a socket for these tiny tubes.

The RK-65 is an u-h-f high power gain tetrode having thoriated Tungsten filament, tantalum plate, grids and shield. The tube may be operated at maximum ratings up to 60 Mc and at reduced output up to 140 Mc.

AS IN 1930-

In 1906 - -

De Forest, working in the realm of physics, invented the vacuum tube. Acheson, meanwhile, laboring in the field of chemistry, first produced Colloidal Graphite.

It is fitting that these two products, born simultaneously, are, after a quarter of a century, intimately associated in the radio industry.

Colloidal Graphite is indispensable in the efficient drawing of tungsten and molybdenum. It discourages grid emission and finds utility as a "getter."

Colloidal Graphite is also a valuable resistance material for grid leaks and volume controls and serves as a long life lubricant for variable condensers and other moving radio parts.

ACHESON OILDAG CO.

Manufacturers of "Aquadag" and "Oildag" brands of Colloidal Graphite.

PORT HURON, MICH.

TENTH ANNIVERSARY

REPRODUCTION OF FIRST ADVERTISEMENT

- SO IN 1940

"dag" COLLOIDAL GRAPHITE CONTRIBUTES TO PROGRESS OF THE INDUSTRY

The versatile graphite films established with the use of "dag" have been employed in many ways in the fields of RADIO and ELECTRONICS.

Colloidal graphite imparts to the surfaces of innumerable bodies properties of lubricating, conductive, absorptive, pigmentary and reflective value. This product is used to advantage in the following: resistances, vacuum tubes, test specimens, thermopiles, evacuated devices, cathode ray tubes, photoelectric cells.

Write for Bulletins 11, 31, 191 and 270 describing how the product functions and how to use it. Perhaps "dag" will be an answer to problems which you may have.

ACHESON COLLOIDS CORPORATION
PORT HURON, MICHIGAN

dag COLLOIDAL PRODUCTS

Trumpets and Driver Units

A NEW LINE of storm-proof Dynamic Reflect Trumpets and Driver Units are announced by Atlas Sound Corp., 1447–51 39th Street, Brooklyn, N. Y. The model illustrated has a six foot air column, bell opening of 29 inches, total depth (including unit and cover) of 31 inches. The new line includes trumpets and units of various sizes to

suit all types of public address applications. The permanent magnet type driver unit is completely enclosed and covered with a streamlined outer shell. The multi-adjustable cast mounting brackets are supplied as complete equipment.

Type K Motor

THIS NEW MOTOR is small in size $2\frac{3}{4}$x$2\frac{3}{4}$x$1\frac{3}{8}$-in. excluding the 5/8-inch long shaft. It weighs less than $1\frac{1}{4}$ lbs. Designed as a capacitor motor, it can be supplied with three different windings—synchronous capacitor, nonsynchronous capacitor, and dynamic braking capacitor. Standard ratings on 60 cycles are, respectively, 1/1500 hp at 1800 rpm, 1/1000 hp at 1700 rpm, and 1/1500 hp at 1200 rpm. Motor input is 8 watts or less.

Operation is at 110 volts ac, and motors wound for lower voltages can be built on order. On higher voltages a transformer is necessary. Motors for lower frequencies can be supplied. Sleeve bearings are standard, ball bearings optional. Principal use is on devices designed for continuous operation, such as industrial controllers, instruments, timers, and similar applications. Bulletin 1024 illustrates and describes in detail this motor which is manufactured by Bodine Electric Co., 2254 W. Ohio St., Chicago.

Attenuator and Conversion Resistors

A DISTORTIONLESS means of controlling the volume of individual loud-speakers in a sound system, is provided by the new Series CIB output attenuator released by Clarostat Mfg. Co., Inc., 285 North 6th St., Brooklyn, N. Y. Capable of dissipating 10 watts at any setting, this unit is a junior version of the

New 7-INCH PORTABLES with extra long scale

FOR LABORATORY, COMMERCIAL AND INDUSTRIAL TESTING

TRIPLETT

- **7-Inch Instrument with 6-Inch Scale.**
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MODELS 725-735 Portables may be obtained in standard and special ranges, including instruments of extreme sensitivity for laboratory use—as well as those for general commercial and industrial testing purposes. The large 7-inch instrument has a long six-inch mirror scale, maximum dial opening, and knife-edge pointer to assure quick accurate readings. Accuracy within 1% (½% for many ranges). Available in microammeters, milliammeters, ammeters, voltmeters, millivoltmeters, thermo-ammeters—multiple or single ranges. Case is quarter-sawed golden oak, 11" x 9" x 4", with handle and detachable cover. Black bakelite panel.

Pocket Size
VOLT-OHM-MILLIAMMETER

A complete pocket-size Volt - Ohm - Milliammeter with AC-DC Voltage ranges: 0-10-50-250-500-1000 at 1000 ohms per volt; DC Milliamperes 0-1-10-50-250; Low Ohms, ½ to 300; High Ohms to 250,000 with provisions for higher readings by external batteries . . . Molded case and panel.

MODEL 666
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FIT STANDARD MTG. DIMENSIONS

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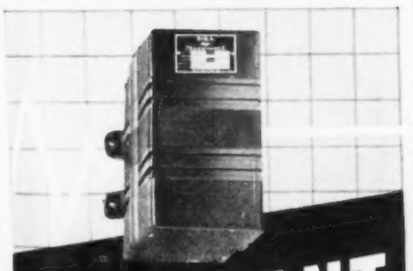

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If your needs call for stable voltage at all times you can depend on SOLA CONSTANT VOLTAGE TRANSFORMERS to deliver for you, even though the incoming line voltage varies *as much as thirty percent.* Practical, economical, trouble-free—they can replace non-regulating transformers or perform as auxiliaries to equipment now in use.

WRITE FOR CATALOG
DCV—22

SOLA
SOLA ELECTRIC CO. 2525 Clybourn Chicago, Illinois

Ave., Chicago, announce their new SX-25 "Super Defiant" receiver, also in the medium priced range. Among some of the features of this receiver are two preselector stages, 4 degrees of selectivity including broad and sharp crystal filter circuits, temperature and line voltage compensation with freedom from tuning drifts, frequency calibrated bandspread on ham bands from 80 to 100 meters, automatic noise limiting, single signal CW reception, a continuous range of 538 kc to 42 Mc in four bands, "S" meter calibrated in "S" units and db, a 6-position switch for selecting phone or CW reception, etc. The circuit employs 12 tubes in r-f stages, mixer-oscillator, 2 i-f stages, detector avc-1st audio, noise limiter, bfo, phase inverter, push-pull output, and rectifier circuits.

Vacuum Thermocouple Meter

IN MODEL 43 POWER output meter of Monarch Mfg. Co., (3341 Belmont Ave., Chicago), a protective circuit has been incorporated which retains all of the desirable features of the vacuum thermocouple and in addition has the ruggedness and high overload capacity of the copper oxide type of rectifier meter. The meter is a Weston model 640 with a long scale (3¾ inches) and open readings over its entire length. The instrument includes means for varying the input impedance between the limits of 3 ohms and 25,000 ohms. This is accomplished by means of a large transformer having suitable taps on its windings. Individually adjusted resistors are connected to all secondary taps to maintain a constant transformer efficiency regardless of which tap is in use. It is possible to determine the output impedance of the source supplying the instrument by varying the impedance of the instrument until the maximum power reading is obtained.

The secondary of the transformer feeds into a ladder type of attenuator network which gives seven power ranges: .03, 1, .3, 1, 3, 10 and 30 watts.

Two-way Speaker System

LANSING MFG. CO., announces that the Iconic System is now available in a new modern console cabinet which is heavily-built and acoustically correct. Measurements are 34x36-ins and it was designed for use in fine residential installations, hotels, cafes, schools, sound studios, etc. Literature on the system is available from the manufacturers located at 6900 McKinley Ave., Los Angeles, Cal.

Universal Meter

AN ALL-PURPOSE portable multi-meter for engineers, television technicians, industrial electricians, etc., is announced by the Radio City Products Co., 88 Park Place, New York City. Model P 411 Super Tester has a full array of

RANGES ✓ ACCURACY ✓ VALUE ✓ DEPENDABILITY ✓ VERSATILITY ✓

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Laboratory Test Equipment

No. 852 Super Sensitive Tester

Designed to meet the requirements of Television, Radio, Industrial and Laboratory.

20,000 OHMS per Volt D.C.

★Seven DC voltage ranges to 5000 v.
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★Eight DC current ranges: 0-50 microamperes to 0-10 AMPS
★Three resistance ranges to 40 megohms (self contained)
★Seven decibel ranges from —12 to +69DB
★Seven output ranges to 5000 volts
★50 microamperes, 4½ inch square type meter with cobalt, magnet 2% D.C.—3% A.C. accuracy

852-P—Closed type with removable cover and tool compartment.. **$41.95**

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AC-DC Volt-Ohm-Decibel-Milliammeter

6000 Volts, AC-DC; 10 Megohms; 12 Amperes

★Six AC and DC voltage ranges to 6000 volts at 1000 ohms per volt
★Six DC current ranges to 12 AMPS
★Four resistance ranges to 10 megohms
★Six decibel ranges from —12 to +70 DB
★400 microamperes, 4½ inch square type meter 2% D.C., 3% A.C. accuracy

844-P—Closed type with removable cover and tool compartment.. **$24.95**

More than 40 models in the PRECISION 1940 LINE . . . 15 Mutual Conductance Tube Tester and Set Tester models ranging in price from as low as $29.95 . . . 16 Multi-Range Tester models from as low as $10.95 . . . Signal Generators from $24.95, etc. . . . See them at your local distributor . . .
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PORTABLE KILOVOLTMETER

TENTH ANNIVERSARY

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Separate multipliers can be furnished for a wide variety of standard instruments used for measuring potentials up to 25,000 volts A.C. or D.C.

Not affected by humidity. Easily adapted for use as resistance standards, particularly those multipliers for use with low current instruments requiring high resistance.

SHALLCROSS "AKRA-OHM" RESISTORS

Type 110—are used in this box, and there are none finer. Calibrated to an accuracy of 0.1 of 1%. Wound with specially insulated resistance wire on precision machined forms made of the finest grade of non-hygroscopic ceramic material available. Moisture proof. *They hold their calibration!*

Write for Kilovoltmeter Bulletin No. 700 KL and Resistor Bulletin No. 122 K2

SHALLCROSS MFG. CO.

Instruments – Resistors – Switches

COLLINGDALE, PA.

25-watt Series CIA attenuator. With neat and compact, one-hole mounting, round black-and-silver etched dial, pointer knob, this unit may be installed in power amplifier or at the individual speaker. Insertion loss is below zero. Db range is in 3 db steps up to 24, and then a 6 db step, with final step to infinity. Stock ohmages are 8, 15, 50, 200, 250 and 500 ohms. These units do not come equipped with power switches. Also available are fluorescent lamp d-c conversion resistors for inclusion in the power circuit of fluorescent lamps.

Timers and Relays

PARAGON ELECTRIC CO., 37 W. Van Buren St., Chicago, have a new series of automatic reset timers and time delay relays designed for precise and economic control of industrial operations. They can be used to close and then reopen a circuit, to open and re-

close a circuit, to make a momentary contact, to repeat a preset schedule of momentary contacts or timed "on" and "off" operations and to reset instantaneously after a power failure. A positive mechanical lock, magnetically operated, eliminates all friction and magnetic clutches and frees the timer of any disconnect due to vibration.

Communications Receivers

TWO NEW COMMUNICATIONS receivers are available. The first is a new radio receiver designed by RCA Mfg. Co. (Camden, N. J.) to provide maximum performance for amateur radio communication, and to find use wherever a radio receiver is required for distant reception. The 10-tube instrument (Model AR-77) has many new features including new treatment of the dials, dual r-f alignment, negative feedback, calibrated bandspread, improved noise limiter, and variable selectivity. The metal cabinet was designed with an eye to convenience of operation and ease of maintenance. An 8 inch permanent magnet dynamic loudspeaker is available for use with the receiver.

Hallicrafters Inc., 2611 S. Indiana

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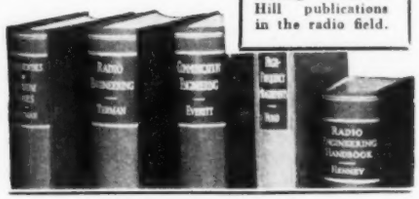
The Library now comprises a revised selection of books culled from leading McGraw-Hill publications in the radio field.



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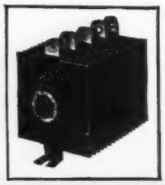

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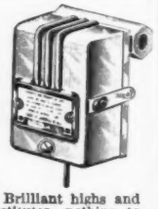
NEW UNIVERSAL
Full Frequency
CUTTING HEAD
U. S. Patent No. 2005154



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330 West 42d St., New York City

a-c and d-c voltage and current measuring ranges. In addition it will read db from minus 10 to plus 69.

Frequency Modulation Components

THE BROWNING Laboratories, Winchester, Mass., announced component parts for receiving wide-band frequency modulation stations. Special broad-band 3 Mc i-f and detection transformers are available as well as a special high frequency tuner. A completely wired and aligned adapter is in production which may be plugged into the phonograph jack of any receiver. Bulletin 105A lists the components and includes a circuit wiring diagram of a complete receiver.

Automatic Reset Timer

R. W. CRAMER CO., INC., Centerbrook, Conn., announce RS automatic reset timer which is a very compact industrial instrument for automatic, accurate timing of a variety of electrical circuits. The timer consists essentially of an enclosed snap action switch unit actuated by an operating arm driven in one direction by a small synchronous motor with an enclosed

magnetically operated gear clutch and a spring resetting means to the starting position after the time cycle has been completed. The time settings are easily adjusted by setting the pointer to the desired time scale. Several time ranges are available to meet various timing requirements. The contact has a capacity of 10 amps at 115 volts or 5 amps at 230 volts. The instrument can be furnished for flush panel mounting or in a dustproof die cast case suited for BX or conduit wiring.

High Vacuum Gauge

THE F. J. STOKES Machine Co., Philadelphia, Pa., has available a new model portable high vacuum gauge with a range from 0 to 700 microns and calibrated down to 1/10 micron. This gauge is designed to enable any unskilled operator to take readings quickly and accurately and is built to withstand hard service and constant handling without danger of breakage or damage.

EBY

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All Molded

STANDARD
Brass Barrel
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TENTH ANNIVERSARY

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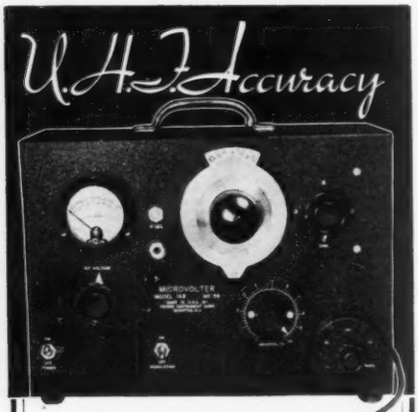

FERRIS MODEL 18-B MICROVOLTER*

- Combination of coils to cover the range of 4 to 150 megacycles
- Output 14 ohms continuously variable from a fraction of a microvolt to 100,000 microvolts over the full frequency range
- Ferris transmission line output system and resistance attenuator
- Write for bulletin E-18B for complete details
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*Reg. U.S. Pat. Off.

FERRIS INSTRUMENT CORPORATION
BOONTON, NEW JERSEY

Patents

Generators. A constant frequency, constant amplitude oscillation generation system. J. N. Whitaker, RCA. No. 2,162,520.

Deflecting Coil. Design of a magnetic circuit for deflecting electrons in a cathode ray tube. W. A. Tolson and I. G. Maloff, RCA. No. 2,155,514.

Frequency Changer. Klaas Posthumus, Eindhoven, RCA. No. 2,190,731.

High Efficiency Resonant Circuit. A high efficiency vacuum tube oscillator for high frequency. W. W. Hansen, Stanford University, Calif., assignor to The Board of Trustees of the Leland Stanford Junior University. No. 2,190,712.

Circuit. Feedback applied to electric discharge circuit. M. A. Edwards, G. E.Co. No. 2,190,775.

Electron Discharge Device. N. M. Rust, and G. F. Brett, London, RCA. No. 2,190,735.

Converter Tube. A converter tube having several grids coated with emitting material and a separate triode oscillator. W. H. Aldous, Wembley, England, No. 2,191,903.

Tubes. A tube in which the second and third grid are of the same pitch and are in alignment, with the second grid connected directly to the cathode. B. O. M. Gall and Jan Bart Hugenholtz, Eindhoven, RCA. No. 2,191,884.

Metal Tube. A metal tube construction making use of a glass stem. C. A. Horn, Roselle Park, N. J. Arcturus Development Co., Newark. No. 2,190,788.

Gas Discharge Tube. H. Kniepkamp. Siemens and Halske, Berlin, Germany. No. 2,192,162.

Television. Method of synchronizing. A. V. Bedford, RCA. No. 2,192,121.

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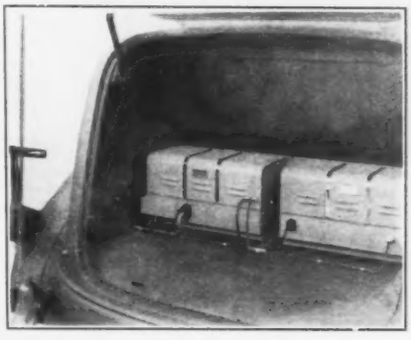

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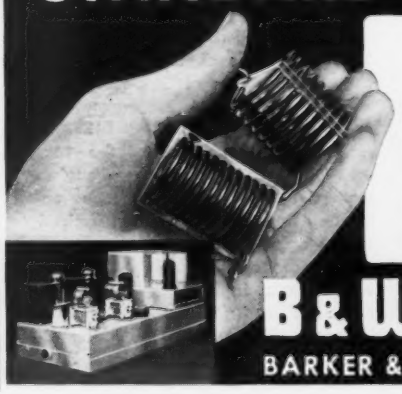

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